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AND ABSTRACT OF THE LITERATURE

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HONORARY CONSULTING EDITOR
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Blood Changes in Lead Workers

The Art, Not the Science, of Industrial Medicine

Hygienic Installations in Modern Industries

Industrial Tuberculosis and the Control of the Factory Dust Problem—Part II

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THE JOURNAL OF INDUSTRIAL HYGIENE

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ORIGIN AND DEVELOPMENT OF THE FACTORY MEDICAL SERVICE IN BELGIUM*

D. GLIBERT, M.D.

Inspector-General and Chief of the Factory Medical Service, Belgium

WITH AN ADDENDUM BY

W. F. DEARDEN, M.R.C.S., D.P.H.

Certifying Factory Surgeon, Manchester

SINCE the creation of the Ministry of Industry and Labor in 1895, the Factory Department has included among its personnel four doctors of medicine. At first there was no differentiation between the duties assigned to the doctors and those exercised by other inspectors. It was their duty to administer regulations of a social and economic character (law governing employment of women and children, workshop regulations, payment of wages, prevention of accidents, etc.) just as, on the other hand, their engineer colleagues attended to the supervision of the hygienic and general health measures prescribed by our factory code. Apart from these appointments, a medical practitioner was, in November, 1895, attached to the central administrative department with a special mission to carry out research work in the field of industrial hygiene and to study any matters bearing on health conditions in factories and workshops.

It soon became evident that the inspection exercised by doctors should be in the direction dictated by their special knowledge and scientific training in questions of physiology and pathology. It was recognised that if the intervention of an engineering expert is indicated in matters of constructional sanitation, safety, prevention of accidents, etc., the collaboration of the doctor is an evident necessity for solving questions of health, and that the study of morbid influences of occupation on the human organism is within his exclusive domain. Daily observation in the very heart of industry itself, and an intimate knowledge of the individual worker render the medical man indispensable as a collaborator with the engineer. The two professions are the complements of each other, and every day experience makes it plain that only good can arise from the respective specialisations assigned to each. It was for this reason that, by a decree of Jan. 31, 1898, the scope of medical inspectors in the provincial service was limited to the administration of regulations concerning health conditions of workplaces and to special inquiries relating to industrial hygiene generally.

The medical inspectors exercised their

* Received for publication August 23, 1920.

functions, under the control of the central administration, over those industries of the country placed under the supervision of the Factory Department. The regions assigned respectively to these doctors were: (1) the districts of Brussels and Louvain, the provinces of Antwerp and Limburg; (2) the two Flanders; (3) the provinces of Liége and Luxemburg and the districts of Namur and Dinant; (4) the province of Hainault and the districts of Nivelle and Philipville. In accordance with this distribution, the medical inspectors made their inquiries into the health of the workpeople in the various trades concerned.

The results of these special inquiries created an evident appreciation of the useful purpose to be served by freeing these medical inspectors from a still greater portion of their actual supervisory functions, in order to enable them specially to devote their energies to research and study in their own particular line. The decree of June 17, 1902,* amending that of Jan. 31, 1898, so delimitated the mission of the medical inspectors. These officers were directed to investigate the general and particular causes of unhealthiness in establishments placed under the supervision of the Factory Department. In this connection, it was incumbent upon them to draw up, in accordance with a model form provided by the central administration, detailed observation notes on the results of their investigations. In addition they were still charged to secure the carrying out of certain requirements of special decrees regulating employment in connection with the manufacture of matches, the manufacture of white lead and other lead compounds, the use of white lead for painting in buildings, the vaccination of workers among rags, the necessary measures to secure first aid in case of factory accidents, and the employment of women after childbirth. Reports of these visits were drawn up and forwarded periodically to the central administration.

The organisation of the medical service was further completed by the addition of a certain number of associated medical practitioners who were charged with the carrying out of medical requirements and rules, prescribed by regulations governing specified factories where work in particularly unhealthy industries is permitted (manufacture of matches, manufacture of white lead, paint work in buildings). These practitioners were also under obligation to notify the department of any features of interest in industrial hygiene to which their attention might be drawn. The number of associated practitioners (whose appointments had to be renewed every three years) was, in 1913, about 150. They were distributed over the principal localities of the kingdom.

Finally, about 1905, a small research laboratory was attached to the central administration. It is here that the current analyses of water, dust, air, etc., are conducted, as well as researches and experiments in industrial physiology and pathology.

Independently of the work of concentrating the information gathered from the provincial medical inspectors, the central administration was directed to investigate from a health point of view the applications submitted to the King for authority to carry on industries which were scheduled as dangerous, unhealthy or unwholesome. It had further the duty of assisting in the co-ordination and elaboration of special rules authorising preventive measures in certain industries and in particularly noxious trades. It was in this connection, notably, that the decrees regulating the utilisation of white lead have been modified under the law of Aug. 20, 1909, and that the royal decrees of Aug. 20, 1908, Aug. 10, 1912, and of Jan. 15, 1914, have prescribed the disinfection of horsehair in brush mak-

* This decree has been completed later by that of Aug. 1, 1906, so far as concerns the supervision of working at white-lead painting.

ing, have regulated in a special manner work in the fur-cutting industry, and have at last settled the conditions of work in compressed air caissons. A considerable proportion of these regulations were, as a matter of fact, placed under the supervision of the medical inspectors, although no fresh decision had increased their administrative functions fixed by the decrees of June 17, 1902, and Aug. 1, 1905.

A fresh rearrangement of the degree of supervision to be assigned to medical inspectors was under consideration in 1914, when the war caused a break in the activities of the service and completely upset the whole administration. Since the armistice the scattered elements of the various prewar projects have been carefully reassembled, and the time has appeared to be opportune, in the course of a general reorganisation of the services, to make a decisive step in the domain of industrial medicine by placing upon its feet an organisation better adapted to the needs of the day. The experience of the war demonstrated, notably in England and in France, that the bringing into being of new methods of working, the intensification of production necessitated by the extent of hostilities, and the steadily increasing participation of the female sex in industry, demanded more and more the close and daily collaboration of the doctor in the regulation of conditions of labor. Our country, which was the first to introduce the medical man as such within the circle of factory inspection, and which had successively rearranged his duties to conform with the needs of the moment and the incessant progress of hygiene in industry, considered it a duty to establish on a new basis the organisation of medical inspection and to extend the intervention of the practitioner to all the domains affecting the social life of the worker.

Up to this period the regulations in force made no provision for the intervention of a medical official in at least half of the great industries. All the establishments, for instance, subject to the supervision of the Administration of Mines — that is to say, coal and metal mines — were inaccessible to him. Again, his intervention in provident matters and insurance was nil. It was now perfectly clear that before the function of the doctor could be further extended the Factory Medical Service must be self-contained and independent of the Factory Inspection Department proper. Actuated by these convictions, the Minister of Industry, Labor and Reconstruction recommended for royal signature the decree of June 25, 1919. This decree, in consecrating the institution of a Factory Medical Service attached to the Ministry of Industry, Labor and Reconstruction, defined its mission in the following terms:

1. To organise the protection of child-bearing or nursing women engaged in industrial occupations.

2. To protect the health of apprentices, and to assist in directing them into the occupation for which they are best fitted (orientation).

3. To study industrial physiology and pathology in all its phases.

4. To bring to bear the special knowledge of its agents on all projects of social providence.

5. To spread among the industrial population a knowledge of the most useful rules of prevention and to bring about the institution of rational methods of promoting health.

6. To supervise the execution of medical regulations.

The actual organisation consists of:

1. Officials attached to the central administration.

2. Officials resident in the provinces whose jurisdiction and place of abode are fixed by the decrees of the Ministry of Industry, Labor, and Reconstruction.

The officials attached to the service must possess either a diploma of doctor of medicine or a diploma of doctor of science.

The program and the responsibilities of the new service being so clearly established, it became essential, in practice, to delimitate in a precise manner the relationship of the organisation with those already existing services which require its active collaboration. At the same time the modifications introduced into the operations of the Factory Department rendered still more necessary such a delimitation. A royal decree, dated Sept. 15, 1919, has regulated the relationship of the medical service with the Factory Department. This decree confers upon the officials of the medical service the status of factory inspectors; it determines their prerogatives in the matter of classing and scheduling of dangerous trades and of dealing with requisitions for authorisation of such classified establishments; it also enumerates the regulations which they are directed to administer. These arrangements cover the preventive and sanitary measures forecasted by the law regulating the employment of women and children, as well as the decree relating to health and safety. Among these decrees may be cited those which provide for first aid to the victims of factory accidents; the vaccination of employees in rag depots; the occupations of loading, discharging, repairing and maintaining ships and boats; the disinfection of hair in brush manufacture; regulation of places temporarily used as lodgings for people employed in brickfields and workyards; the sale, transport and use of white lead in powder, lump, and paste; the utilisation of white lead for painting of buildings; the manufacture of white lead and other compounds of lead; the occupation of fur-cutting; work in caissons under compressed air.

A ministerial decree, dated Oct. 25, 1919, regulates the methods by which this supervision is to be exercised and the administrative interconnections between the Factory Department, factory inspectors, and the medical service. Following out the same ideal, the medical service is to investigate the question of supervising the sanitary measures which up to the present time have been administered by the Department of Mines, and which will now be delegated to medical inspectors. A decree will be promulgated immediately to establish the relationship between the two services.

A program so wide and with attributes so extended inevitably necessitated the enlarging of the list of administrative personnel. As a consequence, to secure the carrying out of the royal decrees of June 30, Sept. 15, and Sept. 30, 1919, the actual list has been so enlarged, and now includes myself, as Chief of the Service, with two principal inspectors, and a chemist attached to the central administration, and one chief inspector with six inspectors attached to the provincial service.

Addendum

The above article is succinct, clear, and unembellished with redundant phraseology, but the information, categorical though it may be, is there and certainly discloses a really wonderful history.

To what extent the results described are due to the untiring energy and persistence of Dr. Glibert, who is himself the medical man referred to as appointed in 1895 to study the medical aspect of industrial conditions, may be conjectured by those who have the honor of his personal acquaintance. The fact remains that, in the comparatively short space of twenty-five years, what might justly be termed an ideal system has been brought into being under his fostering care and management; that he should be placed at the head of the new department is but a fitting compliment to his exceptional abilities both as an organiser and as a man of high scientific attainments.

That Dr. Glibert has been well supported in his efforts there is no doubt. The Belgian race is exceedingly practical and has not been slow to recognise that one of the most important foundations of commercial prosperity is the elimination of waste. What may be termed the artificial production of disability in the worker, through employment in unregulated unhealthy industries or under unhygienic conditions, has been fully recognised as a telling handicap in the economy of production, and this active little nation has certainly not allowed the grass to grow under its feet in tackling this combined medical and economic problem. Of course there is still much to be done before the system can be regarded as complete, but the Belgians have got the machinery and the proper spirit and it may be taken that what has to be done will be done.

Dr. Glibert has quite properly restricted himself to a description of what has already been accomplished but, as a corollary to his article, some reference to the practically matured projects of the Belgian government, in the matter of medical examination and supervision of young people, from 14 to 18 years of age, engaged in industrial pursuits, should be of interest to the readers of this Journal.

Dr. Glibert mentions that among the primary duties attached to the new department, on its foundation, is the protection of the health of apprentices and the rendering of assistance in directing them into occupations for which they are best fitted. One of the first tasks undertaken by the Factory Medical Service was to study this question with a view to adopting a practical scheme of medical supervision of these adolescents. A copy of the draft royal decree, embodying the results of their efforts, with an introductory note and a report on these issued by the Conseil Supérieur d'Hygiène, are published in the first number of the *Bulletin du Service Médical du Travail*, which also contains Dr. Glibert's article. The suggested decree provides for medical examination during the first month of employment, a general re-examination every year and supplementary examinations at the discretion of the district medical inspector. The obligations of the employer are, generally, to render every assistance and, specially, to keep a record of all adolescents in his employ, to be produced to the medical inspector when required; to advise the district inspector, within twelve days of engagement, of the employment of any person under 18 years of age; to advise the medical inspector, during his visits, of any cases of habitual ill health or loss of time through sickness; to provide a suitable private room for medical examinations; to pay the examinee for time lost through the examination; to take note of recommendations for safeguarding the physical development of doubtful cases.

The examinations are to be made by the agents of the Factory Medical Service, who are to be paid by the government, but may be made by medical men engaged by the employer, at his own expense. Such medical men must be approved by the department, must conduct the examinations in a prescribed form, and must report the results of each visit to the district medical inspector. The examinations may also be made by the employee's own doctor, who must give a certificate in a prescribed form at such times as may be required by the medical inspector. No adolescent who objects to submitting to the medical examination may be employed.

The first paragraph of the introduction makes a definite pronouncement that the government does not propose to cramp or limit the recruiting of industrial workers, but insists that the regulations should, on the contrary, have the effect of improving considerably the economic returns of labor. They do not aim at debarring any appreciable proportion of the industrial population from the workshop or from work, but

rather to supersede the old-fashioned methods of giving assistance by substituting a system of occupational adaptation which will find room for the feeble and undersized. The argument proceeds as follows:

> It is extremely rare to find adolescents of working age incapable of remunerative employment. If we except the functionally impotent and the sick, any adolescent can, without compromising his health, contribute sufficiently to production to earn at least a reasonable proportion of his living. It is a question of observation and of choice of occupational education. Following out this view, the government, in taking account of up-to-date requirements, has thrown over the old fashioned "certificate of physical fitness for employment" in favor of the more logical and more fruitful plan of adapting the work to the measure of individual strength and capacity.
>
> But the realisation of this conception necessarily implies a knowledge of individual value and an appreciation of personal productivity. It implies also the necessity for clear direction, guidance and support under difficult circumstances.
>
> This principle of medical supervision covers all adolescents compelled to work at industrial or commercial undertakings. In the process of advising the adolescents themselves, their parents and their employees, the doctor will create a sense of occupational orientation in the midst of work itself, whilst at the same time pressing his views on individual and occupational prophylaxis.

The document goes on to state that for the greater number, medical supervision will be limited to securing progressive bodily development and the observance of general health principles, but that, in respect to the others, it will be most particular and active; that this intervention will have the effect of apportioning, in the best possible manner, the various kinds of work in accordance with the varying strength and capabilities of the applicants, and will prevent adolescents with defects rendering them particularly liable to accidents from working at dangerous machines or risky processes; that the medical service will keep a careful watch over the weak, and will interest itself in their up-bringing to the extent of influencing the various provident and charitable institutions to render useful and practical assistance during a critical life period; that this health supervision is but an extension of school medical inspection, and that those who are compelled to go directly from the elementary schools to work are as much entitled to this protection as the more fortunate ones who simply transfer to a secondary school.

The draft decree with its introductory note were submitted to the Conseil Supérieur d'Hygiène, which appointed a special committee to consider and report upon the project. The findings of this committee were exceedingly favorable and the writer is of opinion that the views expressed should be quoted *in extenso*. The following paragraphs have therefore been abstracted from the report:

> Every child being capable of work, it is necessary to adapt his activity to his powers.
>
> If this principle be admitted it is evident that the individual value of adolescents must be determined from the point of view of their productivity and that choice of occupation must be governed by their physiological properties. It is from this standpoint that occupational orientation must be studied in every case. The proposed regulations only deal with the fringe of this question and in our opinion they could not very well have gone further.
>
> Occupational orientation is, as a matter of fact, being very extensively studied at the present time, and we think that very interesting conclusions will be forthcoming. The knowledge gained in this subject by certain specialists, and also by those responsible for the care and upbringing of war orphans, permits of the assertion that it is extremely useful in choosing a trade to take into account a whole series of physiological and psychological factors, the portent of which is invariably ignored by both children and parents.
>
> Unfortunately the accumulated observations are not yet sufficiently numerous to justify either generalisations or stable conclusions. It cannot therefore be for the present a case of discharging an obligation on something which has been settled by much research work. The future will throw a light on this subject and produce regulations which the hygienist of today can only vaguely visualise.
>
> The necessary consequence of the higher principle marked out is the medical supervision of adolescents in industry. In effect, it is to the interest of society

to secure that the work imposed on the child is not prejudicial to his normal development, while at the same time allowing him to perfect his trade knowledge by devoting himself quantitatively and qualitatively to the occupation chosen. It is essential to move in this matter if adult workers are to attain the maximum of productivity.

To this end the medical inspector will supervise the general development of all young people working in factories. In the case of the more delicate, he should deal with the special necessities of individual cases and must draw the attention of employers to the hygienic measures which ought to be or must be taken to prevent a retrogressive evolution of their apprentices through the influence of inappropriate occupational activity.

The law has made medical supervision of schoolchildren obligatory. Why should it not continue the sanitary control of adolescents in the workshop?

The work of the adolescent is, in effect, often associated with conditions relatively unfavorable to existence; and the period between 14 and 18 years of age is a critical period of life covering the most critical of all, that of puberty.

It is conceivable that, during the course of apprenticeship, numerous troubles may arise and various morbid states can be established which demand immediate intervention and a rapid application of definite hygienic precautions.

Medical supervision then appears to be indispensable. This will not involve a complete sanitary supervision of children, and will not require the application of a complete therapeutical régime to deal with established troubles. It can only bring about a process of clearing away the anomalies produced by occupational methods, and the hygienic orientation of the young. It cannot do more than that, but it will do that.

Actually to wish for more would be to want the impossible. But to obtain what we do ask will secure that every human organism in process of development shall be watched and guided and orientated to the best possible extent.

The sanitary care of adolescents will educate young people in active methods of prevention and treatment; it will also be of assistance to anti-tuberculosis and anti-syphilitic dispensaries in their important social mission; it will be of service to children by directing the sick to the special centers of treatment which are indicated. Doing its work in this manner, such a sanitary supervision will avoid many difficulties in the matter of keeping medical secrets.

Sanitary supervision will be a useful attachment to medical inspection, when this latter is regularly established everywhere. It is quite possible to imagine a system empowering the medical inspector to inspect the school records of his examinees. Some inconveniences will require dealing with, but there is no doubt that, from a health point of view, it is essential that this record, filled in on commencing education, should accompany the youth during the course of his evolution through school and workshop up to his eighteenth year of age.

The medical study of child labor ought not to lead to a definite conclusion on the subject of treatment, for sanitary care does not involve curative medicine. But it will often bring about the acceptance of certain general prophylactic measures which, though not of an obligatory character, have been established by observation. Sanitary supervision will, incontestably, have a marked influence and will thus facilitate the solution of several problems which we can only touch upon here.

It will help to make apprentices understand that they must choose the trade which is most suitable to their state of health, their capabilities and their powers of resistance. It will also assist the disappearance of the evil results brought about by the frequent changes of employment indulged in by young people. It will collaborate in the bettering of apprenticeship, which should become more complete and regular by the fact that children will be selected in accordance with their natural qualifications.

It will lead to the hatching out of many propositions designed to improve the hygiene of youth and to assure perfect nutrition for all. Notably it will help to create projects for the physical education of the working adolescent, projects which in this country are conspicuous by their absence, though necessarily of the greatest interest.

Sanitary supervision, as it is understood in the project submitted to us, has not yet been organised in other countries, — so we think. In many countries, America principally, there is a strong obsession in favor of the certificate of fitness for employment with a view to protecting the adolescent before entering the workshop. But nowhere has it been declared necessary to control the development of the apprentice after entering the workshop.

It is therefore not possible to determine in a specific manner what the program of the new inspection is to be. The actual form which this supervision is to take can only be usefully defined at a later date, when a sufficiently lengthy experience will be forthcoming.

The committee is of opinion that the medical inspector should for the present

follow the lines of examination carried out by school medical officers, involving attention to height, weight and chest measurements, the development of the skeleton, heart and blood vessels, lungs, hernia, eyes, ears, general physical condition, gonorrhea and syphilis.

As the arguments advanced in the reports are fully explained, very little comment is required. They are not new, and most of them have been advanced from time to time during the past fifty years by certifying surgeons in England. Their real value lies in the fact that they are now promulgated by a government department, which has every intention of giving practical effect to all of them. It is quite evident that this intention is a settled policy with the Belgian government.

The writer does not quite agree that there is no contemporary experience to help the Belgian Factory Medical Service in formulating its plan of action. A system of sanitary supervision of children and young persons up to 16 years of age, though not on the same footing as that designed by Belgium, has been in existence in Britain since 1833, and medical occupational orientation was introduced in 1901, when conditional certificates for employment were authorised. Though these systems are not up-to-date and require some drastic amendment, they have created a very large experience in medical examination of young people, and it would appear that the Belgian Medical Service might acquire useful knowledge, not only from the working and results of the more ancient service, but from the obvious defects which require avoiding.

In their plans for industrial reconstruction the Belgian authorities have started at the root. They have fully recognised the basic principle that the C3 factor is an industrial problem, and are convinced that the ill effects of industry are preventable. They are agreed that a process of selection in accordance with physiological capacity is calculated to place workers at the trades to which they are best suited, and that the proper time to effect this selection is the period when a young person enters upon his trade education. They further intend to protect the properly selected worker against the handicap of unhealthy factories by insisting upon every industrial process being carried out under the best hygienic conditions. The Belgian Factory Medical Service has gallantly and whole-heartedly attacked a huge social problem, and the results of the struggle will be eagerly looked for by a large body of well-wishers and fellow workers in the domain of industrial hygiene.

BLOOD CHANGES IN LEAD WORKERS*

ARTHUR SELLERS, M.D., D.P.H.

Lecturer, Practical Comparative Pathology, University of Manchester; Pathologist, Children's Hospital, Manchester; Research Fellow, Public Health Laboratory, Manchester

IN 1914 the writer published some observations on blood changes in lead workers, based on an investigation made at the Public Health Laboratory, Manchester, at the request of Professor Delépine (Jour. San. Inst., Vol. XXXV, No. 7, p. 328). The chief object of the work was to obtain some information concerning the significance of the presence of punctate basophil granules in the red blood corpuscles of workmen exposed to lead. Twenty-six men were examined, all adult males and most of them employees of the Chloride Electrical Storage Company, Clifton Junction. The chief results obtained are stated in the paper published in the Journal of the Sanitary Institute, but owing to lack of space they are not given in full. During the month of December, 1919, through the interest taken by Dr. Macmillan of Prestwich and the kind assistance of the Chloride Company, it was found possible to re-examine fifteen of the men and to obtain some history of others. It therefore seemed advisable to revise the matter and to report the results of the first investigation in 1914 along with those obtained five years later.

Table 1, Part I, gives the main facts regarding the occupation and clinical history of the men taken in 1914. Case 1 was not exposed to lead, his occupation of soaking wood for five years not involving any contact. He had previously been a packer for five years. He may be taken as a sort of control and representing the average type of man employed as regards general physique. Group II comprises men exposed to lead who appeared to be in good general health in 1914 and who gave no history of recent serious illness or lead poisoning. Group III includes men whose general appearance suggested some degree of impairment, such as rather poor physique or signs of anemia, but the difference between the two groups in these respects was not great.

Patients 24, 25, and 26 were men suffering from definite lead poisoning not acquired at the Chloride Company. They were sent for examination in order to have some data for comparison, and at that time were undergoing bath treatment at the Chloride Company's works. Patient 13 was a joiner and had not been exposed to lead to any considerable degree for about two years. He had had a mild attack of lead colic in 1912, being away from work about four months. Previous to that illness he had been working as a packer or at forming and reducing for about seventeen years. His work as a joiner in the works involved only intermittent and slight exposure to lead.

Excluding Cases 1, 24, 25, and 26, the men working under conditions involving exposure to lead were twenty-two in number, all following their ordinary occupations, and the majority being in good health. Four men appeared slightly anemic and three of these men were of rather poor general physique. Their ages ranged from 26 to 59 years, the average being 35; eleven were under 35 and eleven were 35 or over. The nature of their work was such as to involve a considerable degree of exposure to lead. The Electrical Chloride Company manufactures accumulators on a large scale. The men are under careful supervision and the works are adequately fitted with appliances for reducing risk to

* Received for publication July 12, 1920.

TABLE 1.—EXAMINATIONS AND SUBSEQUENT HISTORIES OF TWENTY-SIX LEAD WORKERS

Part I: Examination in 1914							Part II: Examination in 1919
No.	Age	Occupation	Exposure to Lead in Years	General Health	Blood: General Findings	Blood: Punctate Red Corpuscles	Later History in 1919
Group I. Not exposed to lead							
1	51	packer, 5 yrs. woodsoaker, 5 yrs.	none	good	normal	none	Same work. In good health. Influenza 14 days. No other illness.
Group II. Exposed to lead. In good health. No evidence of lead poisoning							
2	30	forming & reducing	10	good	normal	a few	Same work. No illness. In good health.
3	40	forming & reducing	10	good	normal	a few	Same work. No illness. In good health.
4	41	lead burner	25	good	slight anemia, polychromasia	numerous	Left C.E.S. in 1915. Good health. Same work.
5	27	caster	10 mos.	good	normal	a few	Slight lead colic 1918. Now in good health. Same work.
6	38	paster	4	good	normal	numerous	Same work till 1914. Enlisted. Killed in France.
7	44	furnace man	1½	good	normal	numerous	Same work till 1914. Served in France. Rheumatism for past 9 mos.
8	26	sawyer	7	good; rheumatic fever 5 yrs. ago	normal	none	Same work. Good health. Slight coal gas poisoning 2 years ago.
9	29	tape machine	15	good	normal	none	Same work. No illness. Served in France June, 1916, to March, 1919. Shrapnel wound of abdomen.
10	27	trimmer	7	good	normal	a few	Same work. No illness. Good health.
11	26	sawyer	8	good	normal	none	Same work till Sept., 1918. Lead colic Sept., 1918, to July, 1919. Woodsoaker since. In good health.
12	40	plate stores	16 mos.	good	normal	moderate	Left C.E.S. soon after 1914. No further history.
13	42	packer; forming and reducing	17	lead colic in 1912; ill 4 mos.; joiner since recovery	normal	moderate	Still joiner. In good health. Slight exposure to lead occasionally.
14	31	plate filler	14	typhoid 1908; good	normal	moderate	Left C.E.S. in 1914. Became window cleaner. Now in good health.
15	30	caster	6	good	normal	a few	Same work till 1915. Enlisted. Served in France. In good health.
16	35	caster and packer	15	good	normal	numerous	Same work. Good health. No illness. Submarine work about 8 months, ceasing 4 months ago.
17	36	caster	11	good	normal	very few	Now foreman. Good health. No illness.
Group III. Exposed to lead. Some evidence of slight ill health or defective physique							
18	30	caster	15	slight anemia, good health	slightly abnormal	numerous	Same work. In good health. Influenza 14 days. No other illness.
19	48	tape machine	20	good slightly anemic	slightly abnormal	numerous	Same work till Jan., 1914. No lead poisoning. Died Feb., 1914, from "rupture" and "neuritis."
20	31	caster	18	good slightly anemic	normal	numerous	Same work. No illness. In good health. Submarine work Sept., 1915, to April, 1916.
21	27	moulder	15	good, rather poor physique	polychromasia	moderate	Same work. Charge hand. Good health. Ill 5 weeks with influenza.
22	59	caster	17	good poor physique	normal	moderate	Same work. No illness. Good health.
23	35	caster	16	anemic poor physique	poikilocytosis and polychromasia	numerous	Same work. In good health. Stronger than in 1914. Food poisoning caused by bacon, 3 months duration, Dec., 1917.
Group IV. Cases of definite lead poisoning							
24	37	house painter	24	lead colic; ceased work Nov., 1913	normal	a few	No history.
25	—	painter	25	lead colic, paralysis; no exposure for a month	normal	moderate	No history.
26	57	plumber	many years	exposure ceased 4 mos. ago; lead colic and paralysis	normal	a few	No history.

TABLE 2. — RESULTS OF BLOOD EXAMINATIONS IN 1914

No.	Red Cells per C.Mm.	White Cells per C.Mm.	Per Cent. Hb	Color Index	Differential Count of Leucocytes Percentage of Cells				Punctate Red Cells	Remarks Appearance in Stained Films
					Polymorphonuclears	Lymphocytes	Large Mononuclears	Eosinophiles		
					Group I					
1	4,924,000	8,000	90	1	72	23	4	1	none	Normal.
					Group II					
2	4,824,000	8,000	80	.8	71	25	3	1	a few	Normal apart from punctate reds.
3	4,708,000	8,000	84	.9	70	25	3	2	a few	Normal apart from punctate reds.
4	3,748,000	8,000	60	.8	65	30	4	1	numerous	Some polychromasia.
5	4,032,000	8,000	84	1.0	76	15	8	1	a few	Practically normal.
6	4,148,000	8,000	65	.8	61	36	2	1	numerous	Normal apart from punctate reds.
7	4,244,000	8,000	70	.8	60	33	6	1	numerous	Practically normal apart from punctate reds.
8	5,040,000	6,000	90	1.1	70	23	4	3	none	Normal.
9	5,024,000	6,000	80	.8	76	20	3	1	none	Normal.
10	5,200,000	9,000	70	.7	74	22	3	1	a few	Normal apart from punctate reds.
11	4,800,000	7,000	68	.7	57	38	4	1	none	Normal.
12	4,364,000	8,000	80	.9	58	37	4	1	none	Normal.
13	5,100,000	7,000	90	.9	72	19	8	1	moderate	Normal apart from punctate reds.
14	4,320,000	6,000	74	.8	79	17	3	1	moderate	Normal apart from punctate reds.
15	5,268,000	5,000	95	.9	57	34	3	6	a few	Normal apart from punctate reds.
16	5,248,000	6,000	85	.8	65	29	5	1	numerous	Normal apart from punctate reds.
17	5,116,000	6,000	95	.9	65	34	3	2	a few	Normal apart from punctate reds.
					Group III					
18	3,728,000	8,000	75	1.0	56	37	6	1	numerous	Some polychromasia.
19	3,302,000	8,000	75	1.1	79	17	3	1	numerous	Some polychromasia.
20	3,444,000	8,000	65	1.0	73	23	3	1	numerous	Normal apart from punctate reds.
21	5,100,000	9,000	84	.8	73	24	2	1	moderate	Some polychromasia.
22	4,688,000	9,000	80	.8	70	22	2	6	moderate	Normal apart from punctate reds.
23	3,792,000	7,000	64	.8	63	34	3	1	numerous	Some poikilocytes and polychromasia.
					Group IV					
24	4,400,000	6,000	85	1.0	70	23	2	5	a few	Normal apart from punctate reds.
25	4,200,000	6,000	90	1.1	83	14	2	1	moderate	Normal apart from punctate reds.
26	4,360,000	5,000	82	1.0	58	34	6	1	a few	Normal apart from punctate reds.

a minimum. The duration of exposure varied between ten months and twenty-five years The men were not picked men as regards general physique. They were merely selected as examples of men who had been exposed to lead for fairly long periods of time.

Blood Examinations

Methods. — The blood was usually taken from the ear, in a few cases from the finger, and the usual precautions were observed. In 1914 the red cells were counted with the Thoma-Zeiss apparatus and the white cells

were counted in the same drop of diluted blood as the red cells. The hemoglobin estimation was made with the Miescher modification of the von Fleischl instrument. Dried film preparations on slides were stained by (1) Leishman's stain, and (2) methylene blue after a method advocated by Ruelens.*

In 1919 similar methods were used, except that the white cells were counted by means of the ordinary white counting pipette and dried film preparations were stained by the *post-vitam* method as well as by Leishman's stain and methylene blue. On both occasions the results of the differential count of the leucocytes were based on a count of 250 cells. It was considered advisable to restrict the methods to those in ordinary use for clinical examinations.

The full results of the blood examinations made in 1914 are given in Table 2. Excluding Cases 1, 24, 25, and 26, the following is a summary of the results of Table 2: In 5 cases the red cells were below 4,000,000 per c.mm.; in 18 cases the hemoglobin was below 90 per cent. of the normal; in 17 cases the color index was below 1.0; in 18 cases punctate red cells were present; in 5 cases the blood was somewhat abnormal as seen in stained films.

As regards the leucocytes, the changes were not striking. The chief peculiarity was a relative increase in large mononuclear cells. This term includes the different types of cell classified into several varieties by many authorities. No abnormal leucocytes were found. In some instances there was a diminution in the number of polymorphonuclear cells with an increase of the lymphocytes. A moderate degree of eosinophilia was found in two cases and in both of these punctate reds were present.

The changes present in Cases 24, 25 and 26 (all lead poisoning) were similar to those seen in the other cases, but were not of a very pronounced type. All three men had clinical signs of lead poisoning of a fairly severe kind, but exposure to lead had ceased some time before the examination was made, and they were apparently recovering.

Two definite and easily recognisable blood changes were present in a very large proportion of the cases: (1) a diminution of the hemoglobin, (2) the presence of punctate red cells. As regards the latter condition, the histories of the men showed that it was frequently associated with either a blue line on the gums or a previous history of more or less of a blue line at intervals. In two instances punctate reds were present without any blue line either previously or at the time of examination. In one case a fairly well-marked blue line was seen at the time of examination, but no punctate red cells were found. Thus there was no constant relation between the two conditions.

The granulations may appear after a fairly short exposure to lead, but the present series does not include any case with an exposure shorter than ten months. After they have appeared, they may persist for a considerable length of time after exposure has ceased. Thus, in the three cases of lead poisoning they were found one, four, and eight months after exposure had ceased, and in one instance (Case 13) two years afterwards, though in this instance there was possibly some slight degree of exposure at the time of examination. The number of granulations was small in the lead poisoning cases and afforded no index of the severity of the other signs and symptoms.

In Group II, Table 1, comprising sixteen men, the punctate reds were numerous in 4 instances; moderate or few in 9 instances; and not found in 3 instances. In Group III, comprising six men, the punc-

* Fix in absolute alcohol 15 minutes. Stain 2 minutes. Wash in distilled water till the film becomes pale greenish.

Methylene blue (med. pur)	1 gm.
Bicarbonate of soda	6 gm.
Distilled water	200 c.c.

tate reds were numerous in 4 instances and moderate or few in 2 instances. On the whole, it appears that punctate reds were somewhat more frequently found and in rather larger numbers in men showing some sign of defective health than in healthy individuals.

During the past five years the writer has examined at least fifty films of blood from healthy persons, including adult males and females and children, not exposed to lead. Punctate red cells are found very rarely and in very small numbers in apparently healthy individuals. They occur fairly frequently in various diseases and in cases of poisoning by other agents than lead, but apart from clinical details it is usually easy to recognise a film of blood from a lead worker. The punctate red cells are comparatively numerous. Frequently several are seen in almost every field. The corpuscles containing the granules appear sometimes a little larger than the normal ones but not invariably, and they sometimes stain in slightly abnormal fashion, showing an increased affinity for the blue stain. The granules are sometimes very minute and numerous so that the corpuscle appears as if it were dusted over with a fine powder. Frequently they are larger and less numerous and appear as rounded or slightly irregular blue dots not uniform in size, each corpuscle containing a number of granules, varying from six to twelve or thereabouts. The granules appear to be situated mostly in the periphery of the corpuscle. Various artefacts are seen in a badly made film preparation but there is no real difficulty in recognising the punctate red corpuscles.

At one time it was suggested that a diagnosis of incipient or definite lead poisoning could be made if the punctate red cells exceeded a certain proportion relative to the normal red corpuscles, and two standards were proposed, namely, 100 per million and 300 per million. Table 3 gives a summary of the results of counting the proportion of punctate red cells to the normal corpuscles in the twenty-one cases in which they were found. The enumeration was made by an Ehrlich's stop, fifty fields being counted and the proportion estimated in the usual manner. The proportion was not large in any of the cases of lead poisoning — about 100 per million. The largest number was found in Case 23. This man was fairly muscular and of good physique, but rather anemic looking. He had been a lead worker for sixteen years without any serious illness. About the time the examination was made, he was suffering in general health from loss of sleep and mental anxiety due to the fact that he had to nurse his wife who was suffering from cancer.

TABLE 3. — PROPORTION OF PUNCTATE RED CELLS TO NUMBER OF RED CORPUSCLES

Number of cases	21	
Less than 100 punctate cells per million red cells	3	(14+%)
More than 100 punctate cells per million red cells	4	(19+%)
More than 300 punctate cells per million red cells	14	(66+%)

On the basis of the blood examinations it might be suggested that some of the men were in a critical state; i. e., either actually suffering from lead poisoning of a mild type or threatened with an attack. In fact, it might be urged that there were only five cases (Nos. 8, 9, 11, 12 and 21) where fairly definite changes were not present. If the standard of 300 punctate red cells per million were accepted, at least fourteen men would have been suspended from work. On referring to Table 1, Part II, it will be found that in only two instances was there a history of lead poisoning subsequent to 1914. In Case 5 there was a history of slight lead colic, but it did not occur till 1918 and apparently recovery was rapid. Case 11 also had an attack lasting from September,

1918, to July, 1919, when he resumed work. This man, however, was one of the few who showed practically no blood changes in 1914. It therefore seems clear that the examination of blood films as a routine measure for the control of lead workers, whether undertaken on an estimate of the proportion of red cells containing punctate granules or not, would give

TABLE 4. — RESULTS OF BLOOD EXAMINATIONS IN 1919

No.	Red Cells per C. Mm.	White Cells per C.Mm.	Per Cent. Hb	Color Index	Differential Count of Leucocytes Percentage of Cells				Punctate Red Cells	Reticular Red Cells	Remarks
					Polymorphonuclears	Lymphocytes	Large Mononuclears	Eosinophiles			
1	4,960,000	5,500	90	.9	66	30	3	1	none	none	Normal.
2	5,000,000	5,600	80	.8	75	23	1	1	a few	none	Nearly normal.
3	4,000,000	8,200	80	1.0	67	29	3	1	none	a few	A few abnormal leucocytes.
8	4,800,000	7,300	90	1.0	67	30	2	1	none	none	Normal.
9	5,040,000	8,300	84	.8	66	30	3	1	none	none	A few abnormal leucocytes.
10	5,080,000	4,700	80	.8	63	35	1	1	none	none	Normal.
11	3,844,000	5,900	76	1.0	65	30	4	1	none	none	A few abnormal leucocytes.
13	4,800,000	6,000	90	.9	77	19	3	1	none	none	Normal.
16	4,400,000	8,600	70	.8	70	27	2	1	none	a few	Nearly normal.
17	4,900,000	6,100	90	.9	61	37	1	1	none	none	Normal.
18	5,000,000	5,600	80	.8	75	23	1	1	a few	none	Nearly normal.
20	3,828,000	7,800	70	1.0	77	20	2	1	none	a few	Nearly normal.
21	4,260,000	8,900	76	.9	73	24	2	1	moderate	none	Nearly normal.
22	4,900,000	5,600	90	.9	73	25	1	1	none	none	Normal.
23	4,620,000	4,700	76	.8	78	19	2	1	none	none	A few abnormal leucocytes.

results which would operate very unjustly both for the workmen and the employer. It is probable that many incipient cases of lead poisoning would escape detection, and it is certain that many men in good health would be excluded from their work.

During the month of December, 1919, the writer was able to re-examine fifteen of the men and to get some history of the rest. The men examined were Cases 2, 3, 8, 9, 10, 11, 13, 16, 17, 18, 20, 21, 22, and 23. The clinical histories of the men between 1914 and 1919 is given in Table 1, Part II. Most of them had continued to follow the same or similar employment or at all events had worked under conditions involving more or less exposure to lead. One man worked only till January, 1914 (Case 19). He died the following month from "rupture" and "neuritis," but nothing more definite could be ascertained. Patients 5 and 11 who had lead colic have already been discussed. In both these cases the blood examinations made in 1914 revealed slight changes only and clearly not such as to indicate incipient lead poisoning. In some instances work was interrupted by military service. Case 23 is especially interesting. This man, in 1914, had very decided blood changes and looked ill, but he was never suspended and did not develop signs of lead poisoning. In 1919 he appeared in a good state of health. The conclusion seems irresistible that blood examinations give but little information of value in determining incipient lead poisoning in workers exposed to lead.

In five instances a blue line was present more or less, at intervals in the period between 1914 and 1919. A blue line and punctate reds have the same significance. They indicate absorption of lead and are not necessarily signs of actual lead poisoning. The writer's impression was that, on the whole, the men were in a better state of

health in 1919 than in 1914. The explanation of this is not obvious, but possibly it was due to increased pay and better food.

The results of the blood examinations made in 1919 are given in Table 4. The following is a general summary of these results: The red corpuscles were below 4,000,000 per c.mm. in 2 cases; the hemoglobin percentage was below 90 per cent. in 10 cases; the color index was below 1 in 11 cases; the leucocytes were somewhat increased in 7 cases; punctate red cells were found in 3 cases; granulo-reticular red cells were found in 3 cases; a few abnormal leucocytes were found in 4 cases.

There was a slight degree of anemia in Patients 11 and 20, but both these men appeared in good health. The blood examinations, on the whole, showed some improvement as compared with the results obtained in 1914.

It is a matter of regret that the *post-vitam* method of staining was not adopted in 1914 in addition to the other methods. This method does not seem to be much used as a general routine method of clinical examination in this country. It is an old method and the writer has found it very useful. It is very simple, requires no special apparatus and displays some features not recognisable by other methods. It is specially suitable for the detection of punctate red cells.*

There is no general agreement as to the nature of the punctate red cells in the blood of lead workers. Some authorities regard them as degenerative products. Others consider that they afford evidence of regeneration, not of a perfectly physiological character and therefore indicating a slightly abnormal state of the blood-forming organs. The presence of granulo-reticular forms is strongly in favor of this view since, practically speaking, they are not present in the blood of healthy adults. This series of cases offers a good example of toleration to the toxic effects of lead absorption and one is tempted to suggest that the men who are most likely to develop a tolerance are those in whom the absorption of lead excites the production of punctate red cells, because their blood-forming tissues are capable of responding to the stimulus.

The diagnosis of a case of lead poisoning often presents great difficulty and is usually a matter of inference based on a minute clinical examination. Many cases are perfectly clear from the outset and, therefore, do not become the subject of legal proceedings. It is the obscure and doubtful cases which come under the Workmen's Compensation Act. It would surely be a great benefit if some really reliable means could be found, apart from the symptoms and statements of the man himself, which would enable a medical man to say in any particular instance, "This is," or "this is not a case of lead poisoning." Blood examinations are quite unreliable. They do not afford a definite criterion one way or the other. Some cases of lead poisoning do not show readily recognisable changes in the blood and, on the other hand, definite changes may be present without any other sign of lead poisoning. A blood examination in a case of suspected lead poisoning is only one of numerous other pieces of evidence which must all be considered critically in order to arrive at a diagnosis.

The writer desires to thank Professor Delépine, Dr. Macmillan and the Chloride Company for assistance in various directions.

* A full description will be found in *Traité du Sang* by A. Gilbert and M. Weinberg, Paris, Bailliere, on page 146. Make an ordinary wet film preparation on a slide. Put a drop of 1 in 500 methylene blue on a cover glass. Drop onto the slide. Lute the edges.

THE ART, NOT THE SCIENCE, OF INDUSTRIAL MEDICINE*

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I HAVE attended so many meetings of specialists on so-called industrial relations, employment management, service management, etc., that my mind is in a whirl. The ideas of the different men seem so much at variance, and still all claim to hold the panacea for industrial unrest, that I feel entirely at a loss to know whom to believe. Out of it all, however, there comes distinctly to my mind one thing — that the average American workingman is and wants to be independent. He does not desire to be an object of charity.

This independence of the American workingman was typified in the American doughboy in the Great War; an experience I had in Italy will illustrate the point. We had an ambulance section with the Italian army and it used to be the favorite pastime of this ambulance section to pass up and down Mont Grappa in the middle of the night, going 20 or 30 miles an hour, over a road which I hardly dared ride over when anyone else was on it. On one occasion one of these ambulance cars was out of order and the doughboy in charge of it was lying flat on his back under the car, pounding away in an effort to make the needed repairs. It so happened that the King of Italy passed by and, stopping, said, "I say, what is the matter with your car?" Without even looking out from under the car, the doughboy said, "What the hell business of yours is it what's the matter with this car?" The King replied, "Why, it's none of my business — I was merely trying to be pleasant." From under the car came, "And who the hell are you?" The King answered, "Why, I'm the King of Italy." The pounding did not stop, but from under the car came, "Well, what the hell do you think of that?" This is a true story, I can vouch.

My next story is told, not to show any irreligious tendency, but to bring out the independence and the initiative inborn in the American workingman. I was visiting the catacombs near Rome, and a saintly old priest, telling me of a visit which he had been paid by an American doughboy, said, "These American doughboys have no respect for anything. One was here but a short time ago and I pointed out to him that light and said, 'That light has been burning for two hundred years and has never been out.' He turned around, puffed at it, and said, 'It's out now.'" Can you imagine such men as these wanting any charity from their employers or any "soft" welfare work?

After this digression, I come back to my subject, "The Doctor's and Nurse's Part in Industry." If we, as doctors and nurses, stop to think, we ask ourselves what is our business in industry. Are we in industry to do a charitable act for a kindly disposed employer? Are we in industry to stabilize labor? Are we in industry to make one plant more attractive than another which has no medical supervision? Are we in industry to help carry out some soft, silly, social plan? In my opinion, none of these motives explains our presence in the industrial world. Are we in industry then to buy the goodwill of the employee for the employer or perhaps to gratify an employer's desire to do a community service? Again

* Address given privately to a group of physicians and nurses in industry. Received for publication Aug. 23, 1920.

I say no — these should not be the reasons for our presence here. A change of owner or a change of mind of the present owner would leave us out of a job which, in itself, would not be important, but would make us feel that the work we had done was not a real and permanent contribution to society.

If we grant all that I have said as true, we must then ask ourselves again why we are in industry. In attempting to answer this I fear you will accuse me of being mercenary and cold-blooded, but if you follow me through I believe I can disabuse your minds of such belief.

We are in industry because it is good business. We are in industry to reduce the employer's loss from ill health among his employees — ill health leading to idle machinery, lowered production, etc. The cost of sick employees is too great to permit the taking of no steps to limit the amount of sickness. A medical department is, moreover, essential in industry for the proper carrying out of any scheme for placing men on the jobs for which they are physically fit.

Another of the duties of a doctor or nurse in industry is to protect the employer's rights under the compensation acts and to take care, more economically and more efficiently, of patients for whose professional care the employer is legally liable. A doctor and nurse in industry are essential to the economical and proper conduct of any insurance scheme in which the company participates with its employees. Without such control the insurance scheme would be expensive both in money and in lowered production due to abnormal absences from work.

All these reasons should constitute a good business proposition without frills, that is, a business proposition which resolves itself into safeguarding the health of the employee — this being one interest which capital and labor have found they have absolutely in common. In spite of the fact that this is a business proposition, we find that by meeting these obligations an employer reaps benefits along with his employee which neither of them commonly expects from a strictly business relation.

Granting that the employee's health is a common interest to both the employer and the employee, we next ask ourselves what relation the doctor and nurse must now occupy. Let me say in the beginning that the responsibility of the doctor and nurse is — first, last and always — to their patients. The mere fact that a doctor and nurse have entered industry does not in any way relieve them from the sacredness of their professional obligations. Incidentally, if a strictly professional relation between doctor and patient is maintained, and not the relation of employer and employee, the company will profit most. We cannot expect to have a doctor and a nurse do their best in getting a patient well and keeping him so unless they have the full confidence of the patient. Nor can we expect this full confidence from the patient if the doctor and nurse have converted themselves into a medical police force operating in the pay of the company, or if the patient feels that all his personal confidences are to be passed on to the foremen and superintendents.

I therefore urge upon you to take into consideration the things which you cannot do if you are going to maintain the purely ethical and professional relations which you have accepted. You cannot violate the confidence of patients because you are being paid by someone else for rendering this service to them. You cannot become a medical police force without losing the standing you should have with your patients, and you most certainly will not be able to deliver the service which the company has a right to expect of you. You cannot be unethical with outside practitioners or nurses just because you feel

assured that your salary will continue in any case. You owe something to the medical profession and the medical profession owes something to you.

Your position is unique and, because of this fact, you will be more subject to criticism than the man or the woman in the more common types of practice. In the end you will win more by being the best example of ethical practice in your community. You cannot rightfully expect to hold patients except by doing professional work which will merit their confidence. Unless you pay attention to this point you are putting yourself in the class of the doctor or nurse who does cheap routine work because his salary is assured.

You have no right to look to the company to use any force or compulsion to make patients come to you. If the patients do not want to come to you because you are a good doctor or a good nurse, you do not deserve to have patients. We decry the elimination of competition in all business. We legislate against elimination of competition in big business. Why, then, should we look to our employer to use compulsion to force patients to come to us rather than to a private practitioner? May I, then, emphasize the point that you cannot afford to be anything but the best professional people in your community and, if possible, bear the reputation of doing the best professional work. If you do not keep up to this standard, industry will lose you. The day has gone by when big business employed the cheapest lawyer it could get. The corporation counsel is usually the best man in the country. The corporation medical advisors ought eventually to be on the same plane, and they are fast getting there.

As a matter, then, of good business, not of charity, what ought a medical department include? In my opinion, a good industrial medical department should include: first-aid rooms; a medical clinic fully equipped with X-ray and clinical laboratory to do the best medical and surgical work; a dental clinic with educational features in order to round out and perfect the diagnostic features of the medical clinic; a service of safety and sanitary inspection to look up all accidents occurring in the mills and to cooperate with the engineering department in ordering safety devices, to make sanitary inspections of all the company's properties, and to see to it that insanitary and unsafe conditions and fire hazards are eliminated. I suggest also the providing of a district nursing service, which should be maintained as a nursing service, not as a service for investigating and spying upon employees. My own experience in watching both plans operate has led me to have a very strong conviction against the advisability of using nurses to investigate causes of absences, etc. This work should be done by somebody entirely out of the professional group caring for the health of the employees.

In the larger companies a service of occupational research ought to be maintained. It seems to me very unfitting that the study of relation between disease and occupation be left entirely in the hands of professors at the universities. No matter how well qualified these men may be, the best work cannot be done with the home in one place, the work in another place, the sick man in another place, and the professor who is working out the conclusion in still a fourth place. The ideal position for relating disease to occupation demands that the study be made by a person who lives with the workman, who works with the workman, who treats the workman, and who has a scientific staff in this same relation. Industry should, therefore, take its part in solving these scientific medical problems and it will pay industry in dollars and cents to do so.

I might add also, as a component part of a medical department, a day nursery, al-

though I am not converted to the day nursery idea under all circumstances.

I will not talk at greater length upon the operation of these various branches of a medical department, but would like to point out some of the things which may make for the success of the department as a whole. Some of these points I have already mentioned, one being to maintain always strictly confidential and professional relations with the patients and never to have records accessible to the company except under exactly the same conditions as the records in a physician's private office would be available.

It is highly essential that the medical department itself should never reject any applicant for work except when that applicant has been found dangerous to himself, to others, or to property. No diagnosis should ever be given out except to the patient, whether the patient has already entered the employ of the company or is an applicant. When an applicant has been examined for work, the type of work should be recommended by the physician, who is then acting as the medical advocate of the applicant. The physician should state to the employment bureau what type of work is desirable and what types of work would be to the physical disadvantage of the applicant. The diagnosis should never be given to the employment bureau except upon the request of the applicant.

My next bit of advice will give you a chance to laugh at me. Have attractive assistants. Remember that when a person comes to the medical office he is usually coming because he is sick, and with sickness go irritability and a feeling of being on edge. Now I ask, if you were in that frame of mind and stepped into a doctor's office and found an old crab there to scowl at you, do you think you would feel better or worse? If, however, you were met by someone who smiled and had an attractive personality, was sympathetic and took your grunts with a smile, do you think you would feel better? This, then, is just one of the points in the art of the practice of medicine as distinctive from the science of practice, and the same thing holds true in private practice as well as in industry.

Have only the best equipment — that makes for success and good business. Considering the number of patients you will be called upon to take care of, you cannot afford to have poor equipment nor to let it run down. Remember not to get so busy that you forget the place is getting dirty and grimy, and not to be so filled up with success that you forget you look seedy. Don't turn out lights for the sake of saving electric light bills when it is going to make the place look gloomy. A sick man feels gloomy in a gloomy place.

Have a good business system, have good records, and have them well kept. When a patient steps into a doctor's office it is a comfort to him to have the doctor say, "Why yes, you were in to see me three months ago and had — such a thing — the matter with you." This is not deceiving the patient — it is merely using the record to remind yourself about that patient's previous condition, and it at once establishes a close personal relation between you and the patient.

Do the best work in the community and let it be known that you do it only through the work itself. The character of a man's work is the best advertisement which he can have. And as long as you are a doctor, and as long as you are a nurse, remember that you have a medical obligation to *smile, smile, smile.*

The whole problem divides itself quite logically into the responsibility of the employer and the responsibility of the employee. Up to the present I have been describing how the employer should meet his responsibility, and now I wish to ask you how we can get the employee to assume his responsibility. Of the two, it is far easier to

convince the average employer — the average modern thinking business man — of his responsibility. This he can and usually will meet by the appropriation of money to provide adequate personnel, materials, and the correction of certain physical layouts which are a menace to health. Then, too, the law has stepped in to encourage the employer in meeting his responsibility, while the employee's responsibility can only be met by the employee unaided.

How can we get the employee to take an interest in and to look after his own health? There is only one way, and that is almost exclusively by education. Printed matter with pictures and reminders and funny stories is, to my mind, of very doubtful value, and I think its dissemination by employers is possibly open to the criticism of being too paternalistic when it concerns the community health as distinctive from industrial health. Lectures are poorly attended as a rule. I cannot conceive of enough people attending a lecture on "How to Clean Your Teeth" to warrant spending any money in advertising such a lecture. Of all this class of educational work, pictures are probably of the greatest value, but I do not know how much value these are — certainly not a great deal.

The greatest and most enduring effort is not by any short cut or wholesale method. It is through personal contact established by a good medical department enjoying the confidence of employees, by the daily advice of the doctors and nurses to the individual patients given when they are in receptive mood. Except in an epidemic, I do not believe you can get very many well people to read about health or listen to lectures on it, but people will listen when they are sick. I have often asked myself why this is the case and I have said to myself, "It is because people can seldom visualize themselves as sick, and no one can ever really visualize himself as dead." I have come back, therefore, to the belief that the best method of health education is to take the sick man and tell him why he is sick and what will prevent his being sick in the future. He will believe the things you tell him, and will pass them on to someone else — and so it goes. No short cuts — a lot of work and personal confidence is necessary.

In concluding, I wish to call to your attention the possible by-products of a good industrial medical department. If the doctor has stayed doctor and the nurse stayed nurse, the employer may get as by-products some of the following: He may have learned to know his employees better; his employees may have learned to know him better; he may have received their increased confidence and have established a most desirable avenue of approach to them which could not be duplicated in any other way; and, finally, he may have accomplished a lowering of his labor turnover. But these should not be the reasons for establishing a medical department. It is most essential that an employer should not confuse the by-products with the really basic reasons for establishing the department.

And to you, as doctors and nurses, I say, be proud to be still the doctor or even the "doc," and to be the nurse or "Miss Nursie" all of the time.

In closing, I am going to give to you a schoolboy oath, which has in it, however, certain fundamental truths which you, as doctors and nurses, should not forget just because you have entered industry. This was an old fraternity charge which has stayed with me through all my professional life:

> Worthy Candidate, you are now engaged in the study of medicine, the art of healing, which is, with the possible exception of the ministry, the noblest calling within the scope of human attainment. You will be called upon in the exercise of your profession to guard the mortal part of man, ever bearing in mind that it is formed in the image of its Maker. You

will ofttimes stand between man and his God, the only barrier between him and the dark river which none recross. You will usher into this world of sin and suffering the wee small babe whose very life, frail as the finest thread, will depend upon your skill. In old age, when skill has proven of no avail, you will close the eyes of this mortal frame and consign its immortal occupant to the world from which it came. Do not then yield to any temptation to prostitute your abilities for earthly gain, but so conduct yourself that when the final summons shall come from the Almighty Healer it may of you be said: "Well done, thou good and faithful servant, enter thou into the joys of thy Lord."

HYGIENIC INSTALLATIONS IN MODERN INDUSTRIES*

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IT is not a very long time since the hygiene of workplaces and the well-being of the workpeople, who pass the greater part of their lives there, were, in this country, relegated to the background not only by public bodies and employers of labor, but also by the workpeople themselves. The royal decree of Feb. 28, 1863, dealing with the regulation of dangerous, unhealthy and unwholesome trades, did not secure from a purely hygienic point of view any definite improvement; it was left to the decrees of 1886, 1894 and, finally, to that of 1905, to fix general conditions governing the hygiene of workplaces, proper maintenance and cleanliness, and to prescribe certain hygienic installations. Again, among the requirements of the later decrees, those which concern cloakrooms, lavatories and mealrooms can only be enforced in certain scheduled unhealthy industries. But during the past twenty-five years public opinion on these matters has changed considerably. The establishment of a Ministry of Industry and Labor, the measures brought forward on its initiative, and the resolutions passed at the International Congress of Hygiene and Democracy, held at Brussels in 1903, are sufficient to prove this statement. The workpeople themselves have a better understanding of the necessities of hygiene. Far from being opposed, as they were for a long time, they have become ardent advocates of the new system, and willingly call for its speedy application. Further, the recent re-organization of the medical inspection of factories, now transformed into an autonomous Factory Medical Service, and the ability of the men placed at the head of the service are a sure guarantee that the question of establishing and maintaining hygienic installations for the use of workers will be minutely studied in the future.

It is my desire to present to you a short sketch of the different installations, which, in my opinion, and in the light of present day knowledge, should be established from a hygienic point of view in all industrial establishments, whether large or small; and afterwards to say a few words about the housing of the industrial population. I shall, however, place upon one side, as foreign to my subject, such important questions as heating, ventilation, lighting and cleansing of works. These questions necessitate special studies which it is not my intention to enter upon here.

However important or however modest may be the workshop or factory providing the employment, the workpeople should find, on arrival and sufficiently near the entrance, a secure and convenient place for changing from outdoor attire to working dress, and where any object of value can be left in security. These cloakrooms should be roomy, well ventilated, well lighted by day and night, and comfortably warm. They should be provided, to a number corresponding to the workers employed, with metal lockers, simply and solidly constructed and provided with a key; they should be furnished with benches and serve as restrooms in cases of indisposition or during temporary stoppage of work. Adjoining or inside the cloakroom, according to the importance of the establishment, lavatories should be provided. The necessity for the worker to wash his face and hands regularly before taking a meal should be recognised and the practice established as a universal custom. To

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facilitate this it is necessary to place at his disposal simple and well-constructed washing accommodation. Metal troughs with tip-up basins furnished with separate taps, all of solid construction, should be ample for the purpose.

Contiguous to the local lavatories, or at least within easy distance, the mealroom should be established. In these days it is not permissible for the worker, in the interval between his working hours, to be obliged to take his meal in the corner of the yard or in a passage of the factory, exposed to heat in the summer and to cold and rain in winter, or compelled, if allowed to go outside, to seek refuge within one of the numerous beer shops of the neighborhood. The mealroom, simply fitted up, should be a bright apartment, well aired, well lighted, well heated and provided with plain tables and seats to a number corresponding to the number of employees who will be likely to use it at one time. In addition to the furniture, it should be provided with ovens and heated tables for the workpeople to warm their meals, as well as hot-water kettles and urns for the preparation of coffee or other suitable hot drinks, and fitted with taps supplying potable water of absolute purity. In my opinion, it would be ideal to provide, alongside the dining room, a proper kitchen, where a warm substantial meal could be cooked for the workers at a moderate price. In the light of experience gained in communal kitchens during the war, certain employers are disposed to take up this idea.

Installations so important as those of water closets and urinals should be provided in a separate pavilion. These fitments should be the object of particular care both in setting up and in maintenance. At present several types of closet with automatic flush are in existence, and, in the absence of proper sewer provision, septic tanks can easily be provided. These particular installations, which I regard as an indispensable minimum, can and ought to be established without unnecessary embellishment, but with an air of suitability which will induce, or, shall I say, oblige those who use them to keep them in perfect condition. It is necessary to educate workpeople in cleanliness, and this education should be a mutual undertaking. The workman ought to make it a point of honor to see that places fitted up for his exclusive use are maintained in good condition. To this end he should repress any slackness on the part of his fellow workers, who might be inclined through ill nature or in a boyish prank to damage or dirty the fittings. I have noticed that the placing of inscriptions on the walls of cloakrooms and mealrooms is useful in impressing upon workers their common obligations. It goes without saying that in any establishment employing both sexes, these installations must be duplicated, their scale and extent varying with the respective numbers of males and females normally employed.

It may appear strange that, up to now, I have not mentioned shower-baths; it is not that I have forgotten them, for among modern hygienic installations I regard them as of first importance, but because, however desirous I may be to see their general adoption, I do not think they are indispensable in all industries. By the very nature of his work, whatever it may be, the skin of the manual worker is bound to become covered quickly with impurities prejudicial to the proper carrying out of the functions of this organ. The sole means of clearing them away economically, rapidly and easily is the shower-bath. It is then desirable that establishments of sufficient magnitude should provide shower-baths for their workpeople, and habituate employees to their frequent, if not daily, use.

Up to this point, I have dealt only with installations for the use of healthy workpeople. Modern industry unfortunately carries in its train a series of accidents more

or less severe which, in their turn, call for special measures. I well know that the workshop and the factory are scarcely the most suitable places for curing wounds, but as a first-instance measure or to bring about the safe transference of the injured to the appropriate dispensary, every industrial establishment should possess a special equipment, always available, day or night, to enable the victims of industrial accidents to receive the appropriate first aid and dressing which, without detriment to proper treatment or risk to life, will secure their conveyance in comfort to clinics provided with every appliance necessary for up-to-date treatment. The extent of the first-aid provision will necessarily depend upon the size of the factory, its topographical situation and its distance from or proximity to hospitals or clinics. It is for the medical personnel to fix the exact requirements which these places must fulfill.

My preceding remarks have had relation to industry in general. There are in existence, however, in our country, a number of particularly unhealthy trades which demand special attention from the hygienist. A complete list of these would be too lengthy to give. I ought, however, to mention factories where lead is produced, manipulated or used in its various forms; where dangerous metals — arsenic, antimony, chrome, mercury, etc. — are employed; tar-distilleries and places where derivatives of tar or petrol are produced; gas works; patent fuel works; zinc foundries; glass works; cement works; china and pottery works. In all these factories, not only should cloakrooms, lavatories and dining rooms be obligatory, but it should be made compulsory upon employers to provide shower-baths and upon the workpeople to make use of them. The latter will not be so difficult to deal with as one is often led to believe, judging from experience of coal mines where the most rebellious to commence with are now the most ardent advocates of these useful additions. At the present time shower-baths are only compulsory for coal mines, but in my opinion all underground workings of any importance should have them provided.

Our shower-bath installations are well known and they are being improved upon every day. The most up-to-date nearly all conform to one type, consisting of a spacious room in the center of the building, which serves as a dressing room and where the older clothes hooks have given place to metallic lockers for the full complement of the working personnel, the wings being fitted up with bath compartments, lined with enamelled bricks to facilitate cleansing. The rooms are well ventilated, well lighted and maintained at an even temperature of 18° to 20° C. during the most rigorous weather. The dressing rooms are now provided with tool-chests for the accommodation of articles too weighty to be hung up with safety.

Such are, to my mind, the installations most indispensable to modern industry. I should like to see their daily extension an established practice, and this because private enterprise realises that the well-being of the worker is not simply a social duty but an important factor in production.

Before concluding I should like to say a few words about hygienic installations in the homes of the workpeople themselves. The workman does not pass the whole of his existence in the factory or workshop. The most of his time is devoted to home life, and consequently this should be rendered as pleasant and healthy as possible. I have neither the ability nor the time to discuss the big question of housing the working classes; I simply desire to indicate certain hygienic conditions which require attention. The miserable tenements which we know so well must go. In their place ought to be and are being established, along wide avenues planted with trees with a full

complement of light and sun, groups of workmen's houses within their own little gardens, forming what are known as "garden cities." Why not provide in each of these houses, in place of the more than rudimentary fittings with which we are familiar, water closets of a sensible and hygienic type, a constant supply of potable water, and, as one often sees in quite modern English homes, hot-water systems, kept going by the ordinary kitchen fire, with bathrooms, provided at least with shower-baths, where each member of a family can in turn go through the daily cleansing process, so necessary to parents and children alike when the labors or games of the day are ended.

Should the cost of these individual installations be prohibitive, at the very least there should be provided for each garden city a well-equipped bathhouse sufficient for the use of all the inhabitants. Why not also establish in the same building a communal washhouse for the family linen, or at least a common scullery for housewives to do their own washing, thus removing from the living quarters, as is really necessary, the emanations from the soap-suds and dirty water which are so prejudicial to domestic hygiene? I should like to see in the center of these garden cities, side by side with the primary school, the housewifery school and any other desirable educational institution, a hall for social gatherings, conferences, concerts or cinemas, together with a library, for the purpose of occupying and giving charm to the leisure moments which the shortening of the working day will considerably augment and which it is desirable should be rendered fruitful. It is there also that we should find the child welfare center, so necessary to the development of the younger generation, and the dispensary hospital for the proper treatment of injuries and severe illnesses.

It is not, believe me, the kingdom of Utopia which I have been picturing. All these installations are in existence in France, notably at a number of large coal mines of the Nord and the Pas-de-Calais. Many of our mines of the Campine have put in hand or have already completed similar projects and other large works have set the same example. But in this domain there is yet much to accomplish and it is only combined effort and hearty goodwill that can produce for our workpeople in a renovated Belgium hygienic installations worthy of the epoch.

INDUSTRIAL TUBERCULOSIS AND THE CONTROL OF THE FACTORY DUST PROBLEM *

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PART II

Methods of Studying Dust Content of Air

IN view of the serious effects produced by mineral dusts in the employments noted in Part I of this paper, it seems evident that the exact determination of the dust content of the atmosphere becomes a matter of considerable importance. We need such data, first of all, in order to estimate the extent of the hazard involved in various industrial processes and, second, to measure the efficiency of various protective devices which may be introduced for the mitigation of the dust hazard.

The technical difficulties involved in the problem of dust determination are of considerable complexity, and it is of primary importance to determine the size of dust particles which we desire to include in such examination. It seems clear that any useful method of examination must include particles ranging down to 1 micron in diameter. The studies of the South African Commission (9) (10) (11) indicate that particles even 12 microns in diameter are of negligible importance, since such particles are rarely present in the fibrotic lung. Methods which reveal only the very large particles present in the air are, therefore, of little value. To this class of dust-counting procedures we must relegate most of the attempts so far made in this country to collect dust particles by causing a current of air to impinge against a surface covered with glycerine or some other adhesive material.

The earlier procedures of this kind soon proved unsatisfactory, but a device of this type has again been advocated by Dr. E. Vernon Hill of the Chicago Department of Health (15). Dr. Hill's dust counter consists of an exhaust pump for producing the movement of the air and a small capsule or shield fixed at the end of the pump, carrying a cover-glass covered with adhesive material for catching and retaining the dust. Dr. Hill has tested the accuracy of this apparatus by setting up six or more capsules in succession in series and causing the air to impinge upon one plate after another in succession. From this test he concludes that the first plate takes out 62 per cent. of the dust present. It seems obvious, however, that the removal of a particle of a given size and weight by an apparatus of this kind will depend primarily upon the velocity with which the air current approaches the adhesive plate. Large and heavy particles will be thrown against the first plate. Small and light particles, the momentum of which is so slight that they are carried round the first plate, will be carried round any number of plates that may be placed in series, so that this method of controlling the accuracy of the results obtained is valueless. The actual counts obtained by Dr. Hill are so exceedingly low (from 500 to 1500 particles per cubic foot in clean outdoor air and

* Part I of this article appeared in the preceding issue of the Journal of Industrial Hygiene.

from 10,000 to 30,000 in ordinary schoolroom air) as to make it reasonably clear that his sampling device retains only a small fraction of the dust particles actually present.

On the other hand, it is possible in the estimation of atmospheric dust to err in the other direction, by including particles too small to be of any sanitary significance. The point in which we are interested as public health workers is the differentiation between the ordinary normal atmosphere and the air of dusty factory workrooms such as we know to be dangerous to health. This difference is sharply marked so far as the dust particles between 1 and 10 microns in diameter are concerned, but the difference between such normal and abnormal air is masked and lost when we include in our determination the particles of ultramicroscopic size which are present in vast numbers in all air. These very minute particles can be estimated by such optical devices as the koniscope and the dust counter introduced by Aitken. Macfadyen and Lunt (16), for example, report 9,000,000,000 dust particles per cubic foot in ordinary indoor air by the use of the Aitken dust counter. Such results as this tend only to mask the really significant differences in particles of small but appreciable size which distinguish the normal atmosphere from the air of a dusty grinding shop.

If these conclusions are correct, the desideratum is a method which will reveal with reasonable accuracy the number of dust particles of a diameter between 10 microns and 1 micron (about the lowest limit of clear microscopic visibility with the magnification used in our dust analyses). The weight of dust present is interesting but much less important than the number of dust particles, since one very large particle will be less injurious to the lung tissue than a number of smaller ones.

There are three methods in use at the present time which appear to meet these practical requirements—the Palmer water-spray apparatus, the Kotzé konimeter, and the Bill electrostatic method.

The Palmer apparatus (17) was devised after a careful study of the inaccurate sugar filter method, the Graham Rogers glycerinated plate (which was a precursor of the Hill dust counter), and various other earlier procedures. The air to be sampled is drawn through water in a shallow trap at such a rate as to break the water up into a fine shower of spray in a glass bulb above, and this spray retains the dust in the air and finally washes it down into the trap. After the completion of a run, the dust which has accumulated in the water may be estimated by direct microscopic enumeration of the number of particles in a Sedgwick-Rafter cell and by weighing the dust after filtration through a Gooch crucible. This procedure was recommended for ordinary routine use in the *Final Report of the Committee on Standard Methods for the Examination of Air* of the Laboratory Section of the American Public Health Association (18).

The Kotzé konimeter, devised by a member of the South African Miners' Phthisis Commission, is based on exactly the same principle as the Hill dust counter, but the diameter of the nozzle through which the air passes is very small and the air is drawn through this small opening by a piston rod moved with great rapidity by a brass spring, so that the velocity of the air impinging on the plate is sufficient to give a practically complete sample of even the minute particles of dust. The strength of the piston spring is sufficient to give a calculated velocity of air to the impinging nozzle of not less than 30 or more than 80 m. per second, and the slide for collecting the dust is coated with vaseline. This apparatus is described in detail in the final report of the South African Commission (11), and results obtained by its use have recently been presented by Inness (19).

The Kotzé konimeter seems to be an admirable piece of apparatus and it is most desirable that careful tests should be made of its value as compared with the Palmer sampler. The South African workers dismissed the Palmer apparatus from consideration under a misapprehension, stating that particles under 10 microns in diameter are ignored in the Palmer count, which is, of course, not the case.

The third procedure, which has recently been suggested for the determination of atmospheric dust, is the electrostatic precipitation method described by Bill (20). This apparatus is apparently the most accurate yet devised for the determination of dust particles of the sizes which are of chief sanitary significance. Very careful comparative studies by Dr. Bill showed that the counts obtained by the Palmer apparatus averaged about 62 per cent. of those derived by electrostatic precipitation. A still more recent study by Fieldner (21) gives an efficiency of 40 to 50 per cent. for the Palmer apparatus (only 30 per cent. when compared to the results obtained by optical examination with silica dust, and only 13 per cent. with tobacco smoke — which well illustrates the fallacy of the optical methods as criteria of dust particles of sanitary significance). Dr. Bill's electrostatic apparatus is certainly deserving of most thorough study, but in its present form it is too bulky for ordinary field work. Dr. Bill concludes that the Palmer procedure "represents the best method of dust collection for its purpose that we now have."

The Committee on Standard Methods for the Examination of Air of the Laboratory Section of the American Public Health Association in its Fourth (Supplementary) Report (22) arrives at the same conclusion in the following terms:

> It seems evident to your committee that there are three distinct methods which may be used with reasonable success for the determination of the dust content of the air. Their special advantages and disadvantages appear to be as follows:
>
> The Palmer water spray apparatus is fairly convenient and portable and permits the determination of the total weight of dust as well as the number of particles in a given sample. It yields however only about 60 per cent. of the total dust present in the air.
>
> The Kotzé konimeter is even more convenient and portable than the Palmer water spray apparatus, but it is not possible by its use to determine the weight of dust as well as the number of particles present. Exact comparative data as to the proportion of dust obtained by these two methods are not at present available.
>
> The Bill electrostatic method yields more accurate results than those obtained by the Palmer apparatus and could of course be used for determining counts as well as weights of dust. On the other hand the apparatus is not as yet in a form sufficiently convenient for ordinary field work.
>
> With all the facts in mind we are inclined to recommend that the Palmer water spray apparatus be retained for the present as the standard method for the determination of the dust content of air. It seems probable that the failure to collect all the dust actually found to be present by the electrostatic method will not seriously affect the relative values obtained in different environments. Recent studies of actual atmospheric conditions in industrial plants (23) (24) (25) . . . have shown that the Palmer method yields clean cut and satisfactory results, high counts being obtained in shops which are dangerously dusty and low counts being uniformly obtainable by the application of recognised methods of dust removal.
>
> If later studies should indicate that the Kotzé konimeter yields materially higher results than the Palmer water spray apparatus, or if the Bill electrostatic collector should be made portable and convenient for field work, one or the other of these two devices should be adopted; but for the present we believe it is wisest to retain the Palmer apparatus for ordinary sanitary use.

Variations in Dust Content of Air from Normal and Industrial Environments

In order to obtain a conception of the seriousness of the dust hazard in a given industry it is important to review the variations which exist in the normal atmosphere and in the air of various types of industrial establishments. In the present discussion

all the data considered have been obtained by the Palmer method — the only one extensively used in this country — so that all the results are fairly comparable.

The dust content of pure outdoor country air is fairly represented by the results which are summarized in Table 8. The number of dust particles in this and succeeding tables refers only to what Palmer has called "$\frac{1}{4}$ standard unit particles" — particles of a diameter less than 10 microns and down to the limit of ready recognition under the microscope (1 micron or somewhat less). The number of larger particles present is always relatively very small.

November 26 was a rainy day and December 1 was a clear day following a rain thirty-six hours before, and these results may be taken to indicate about the minimum likely to be obtained in pure outdoor air.

To illustrate the results characteristic of the air of city streets and of occupied spaces indoors, free from any special dust hazard, we may cite the results in Table 9 from a paper by Palmer, Coleman, and Ward (26). It is interesting to note that of the three samples collected outside the Woolworth Building one from the street level showed 118,000 particles per cubic foot, one from a window on the tenth floor, 72,000, and one from a window on the fifty-eighth floor, 23,000.

Finally, in Table 10 we have collected a considerable series of determinations of the average dust content of the air in various types of industrial establishments from our own results, from those of Palmer, Coleman and Ward, to which reference has just been made, and from a paper by Miller and Smyth (23). The figures are arranged in ascending order according to the number of dust particles present.

The results presented in Table 10 illustrate well the range in dust counts to be expected under practical conditions — from values between 100,000 and 200,000 dust particles per cubic foot in factories where the dust problem is well cared for to figures one hundred or even one thousand

TABLE 8. — DUST CONTENT OF PURE COUNTRY AIR, RACEBROOK COUNTRY CLUB, NEW HAVEN

Date	No. of Samples	Dust Particles per Cu. Ft.			Mg. of Dust per Cu. Ft.		
		Minimum	Maximum	Average	Minimum	Maximum	Average
November 21	3	43,800	59,600	50,300	0.0001	0.0053	0.0031
November 24	6	16,200	30,500	22,100	....	....	....
November 26	5	5,200	8,500	7,100	....	....	....
December 1	4	5,700	12,200	9,300	....	....	....

TABLE 9. — DUST CONTENT OF AIR OF CITY STREETS AND OCCUPIED SPACES WHERE NO SPECIAL DUST HAZARD EXISTS

Source of Samples	No. of Samples	Dust Particles per Cu. Ft.			Mg. of Dust per Cu. Ft.		
		Minimum	Maximum	Average	Minimum	Maximum	Average
Outside balcony, city college	3	125,000	199,000	153,000	0.0000	0.0037	0.0012
Outside Woolworth Building	3	23,000	118,000	72,000	0.0048	0.0310	0.0150
Business office	2	128,000	172,000	150,000	0.0056	0.0125	0.0090
Department store	4	94,000	118,000	108,000	0.0056	0.0278	0.0153

times as great in the worst types of grinding shops and abrasive factories. The character of the dust present must, of course, be taken into account in considering the sanitary significance of these figures, large counts in such places as the cement mill and the mattress renovating factory being obviously of much less moment than lower values in the mineral industries.

It is interesting to notice from this table the comparatively slight significance of the determination of the weight of the dust present which is so markedly influenced by the presence of a comparatively few large particles. Thus, the feather drying factory showed the third largest dust content in the table by weight, as a result of the presence of the starch used in the treatment of the feathers — an aerial contamination which has presumably no harmful influence upon the health of the workers. The fourth highest weight in the table is exhibited by the cement mill which again involves a dust of relatively slight harmful possibilities. The enormous weight of the dust found in the air of the sand-blast chamber is, of course, due to the presence of large fragments of the sand used in the process. It is, however, somewhat surprising to note that, in spite of the presence of this great quantity of dust as shown by weight, the actual number of small particles present is less than in the air of one of the abrasive factories studied — air which to the senses would appear infinitely purer than that of the sand-blast cabinet. The abrasive factory in question apparently represents the worst condition from the standpoint of industrial dust that has yet been reported (25).

TABLE 10. — DETERMINATIONS OF AVERAGE DUST CONTENT OF AIR IN VARIOUS TYPES OF INDUSTRIAL ESTABLISHMENTS

Source of Samples	Observer	No. of Samples	Average Dust Particles per Cu. Ft.	Average Mg. of Dust per Cu. Ft.
Cigar shop	Miller and Smyth	19	103,000	0.0840
Good pearl button factory	Palmer, Coleman and Ward	5	106,000	0.0001
Blanket plush and carpet	Miller and Smyth	13	149,000	0.5040
Good dry grinding shop	Winslow and Greenburg	10	154,000	0.0548
Pottery	Miller and Smyth	5	183,000	0.1300
Good light polishing shop	Winslow, Greenburg and Angermyer	8	195,000	0.0181
Good heavy polishing shop	Winslow, Greenburg and Angermyer	7	204,000	0.0300
Rag sorting	Palmer, Coleman and Ward	5	337,000	0.1352
Feather drying (with starch)	Palmer, Coleman and Ward	5	484,000	2.6000
Steel grinding	Miller and Smyth	3	490,000	0.4330
Asbestos	Miller and Smyth	6	494,000	0.3540
Fur hat factory	Palmer, Coleman and Ward	5	599,000	0.1025
Marble cutting	Palmer, Coleman and Ward	4	648,000	0.0607
Flint mill	Miller and Smyth	3	844,000	0.4590
Iron grinding	Palmer, Coleman and Ward	4	2,086,000	0.1297
Mattress renovating	Palmer, Coleman and Ward	5	3,750,000	0.3613
Cement mill	Miller and Smyth	11	6,791,000	2.1850
Axe grinding shop	Winslow and Greenburg	32	15,800,000	0.4140
Abrasive factory B	Winslow, Greenburg and Greenberg	57	31,010,000	1.7430
Sand-blast chamber	Winslow, Greenburg and Reeves	10	60,880,000	55.2900
Abrasive factory C	Winslow, Greenburg and Greenberg	9	159,779,000	7.8050

Control of Dust Hazard by Substitution of Wet for Dry Processes

Having reviewed the relation between industrial dusts and tuberculosis and the

extent of the dust hazard in various industries, it remains to consider the measures which may be taken to control this danger and the success which they have attained, as measured by determinations of the actual dust content of the air.

There are, in general, four different methods of protecting the worker against the influences of industrial dusts, which may be classified as follows: the substitution of wet processes for dry processes; the conduct of dust-producing operations in enclosed chambers; the removal of dust by hoods equipped with exhaust draft; and the use of respirators and helmets.

The most successful example of the use of moisture for decreasing the danger from atmospheric dust is perhaps to be found in the measures taken to protect the worker in the South African metal mines. Table 11, for example, from the 1916 report of the Miners' Phthisis Prevention Committee (with weights changed from milligrams per cubic meter to milligrams per cubic foot) shows the effect upon the composition of the air at the top of the upcast shaft of a mine of the application of a general system of underground spraying.

In many other industrial processes the use of water is highly effective in the control of dangerous dusts, as in the wet grinding of white lead, and the analogous process of rubbing down lead paint with pumice and oil instead of sandpaper. We must be on guard, however, against the assumption that a process is necessarily free from dust because water is used in connection with it.

This fact was forcibly borne in upon us by the study of the conditions in the Connecticut axe factory which have been discussed in Part I of this paper. The predominant process in this factory was wet grinding, and the few dry grinding shops in operation were in excellent condition as will be pointed out further on. The enormous tuberculosis mortality of 1900 per 100,000 among the polishers and grinders in this plant must, therefore, be due to dust produced in the process of wet grinding, which the standard texts on industrial hygiene generally assume to be harmless — an assumption which was also entertained by the officials of the axe factory in question.

Our study of the actual conditions soon indicated that the confidence in wet grinding was wholly illusory. The grinding

TABLE 11.—DUST CONTENT OF AIR OF SOUTH AFRICAN MINE IN MILLIGRAMS PER CUBIC FOOT

Hour	Sept., 1911 No Sprays	April, 1912 Sprays in Use	Sept., 1912 Additional Sprays in Use
9 A.M.–10 A.M.	7.9	0.9	0.10
11.30 A.M.–12.30 P.M.	3.7	0.6	0.06
2 P.M.–3 P.M.	2.3	1.1	0.60
4.15 P.M.–5.15 P.M.	2.8	0.4	0.50

wheels at this plant were of natural sandstone, so friable that a stone originally 72 inches in diameter, when used to grind axes, is reduced to a diameter of 29 inches (at which point it is discarded) in about one month. A stream of water from a 1-inch pipe is continuously discharged upon the wheel but the amount of this water is regulated by the worker and is kept down to a small amount to avoid splashing and to facilitate rapid work. The operators bear down very heavily upon the wheel in grinding and the net result, as indicated in Table 12, is the generation of enormous quantities of dust.

It appears evident, then, that while the use of moisture is sometimes successful in controlling the dust hazard, this procedure may or may not be effective, depending on the details of the process and the method by which the water is applied. The only way to determine its efficacy in a given case is by a study of the actual dust content of the air.

Control of Dust Hazard by Conduct of Dust-Producing Operations in Enclosed Chambers

A second method of controlling the dust hazard consists in the carrying out of dust-producing processes, such as sifting, crushing, tumbling, and the like, by mechanical devices in enclosed chambers. In dealing with poisonous dusts, like that which is encountered in white lead manufacture, this type of device has proved notably successful.

Here again, however, as in the case of the application of moisture, the efficiency of the particular installation depends on the care with which the details of design and operation have been carried out. In Table 13 are summarized the results of our examinations of the air of two workrooms in which tumbling barrels were used, one installation being effective and the other quite inadequate. The first process was inherently less dusty than the second, consisting of the polishing of metal pieces in sawdust, and the tumbling barrels were well constructed and tightly closed. The second process involved the removal of scale from castings and, although conducted in supposedly closed barrels and provided with an exhaust, the barrels and the exhaust system were in such poor repair that the air of the workroom was exceedingly dusty. From these results, then, it is once more evident that the real efficiency of a given device for controlling the dust hazard can only be determined by actual examination of the air of the workroom.

Control of Dust Hazard by Operation of Hoods and Local Exhaust Ventilation

There will always remain many industrial processes, such as certain types of grinding and polishing, which cannot be carried on by wet methods or in enclosed chambers. The most obvious, and the most generally satisfactory method to be used for the protection of the worker in such cases is the provision of properly designed hoods equipped with a system of exhaust ventilation sufficiently powerful to remove the dust as it is produced and to carry it away from the workroom.

The excellent results which may be obtained from the use of a system of this kind are well illustrated by the analytical data for the dry grinding shop and the two polishing shops included in Table 10 and more fully presented, with minimum and maximum figures, in Table 14. It is of interest to notice that the dry grinding shop in question was situated in the same Connecticut axe factory which furnished the wet grinding results summarized in Table 12. The management in this plant was somewhat concerned about a possible health hazard in its dry grinding department but assumed that its wet grinders were in no danger; whereas the exhaust system in operation kept the air of the dry grinding shop in excellent condition and the wet grinding shop was, as a matter of fact, exceedingly dusty.

The chief conditions essential to the success of an exhaust system for the removal of dust from grinding and polishing wheels are four in number: the design of the hoods themselves so that the point where the dust is generated may be covered as completely as possible without interfering with the work, and as closely as possible so that a full suction velocity may be maintained; the arrangement of the suction draft so that it may operate with and not against the centrifugal force which throws the dust particles from the wheel; the elimination of all obstacles between the hood and the main exhaust duct which may decrease the velocity of suction; and the maintenance of an adequate suction head in the main exhaust duct itself.

TABLE 12.—DUST CONTENT OF AIR IN WET GRINDING SHOPS OF AN AXE FACTORY

No. of Samples	Dust Particles per Cu. Ft.			Mg. of Dust per Cu. Ft.		
	Minimum	Maximum	Average	Minimum	Maximum	Average
32	870,000 [1]	50,000,000	15,800,000	0.0790	2.1600	0.4140

[1] This was the only sample below a million. The next lowest count was 1,900,000.

TABLE 13.—CONTRAST BETWEEN DUST CONTENT OF AIR IN A GOOD AND A BAD TUMBLING ROOM

Room	Condition of Tumbling Barrels and Exhaust	No. of Samples	Dust Particles per Cu. Ft.			Mg. of Dust per Cu. Ft.		
			Minimum	Maximum	Average	Minimum	Maximum	Average
A	Good	2	102,000	261,000	181,000	0.0177	0.0517	0.0347
B	Bad	6	2,940,000	11,400,000	6,250,000	0.0760	2.7800	0.9212

TABLE 14.—DUST CONTENT OF AIR IN GRINDING AND POLISHING SHOPS EQUIPPED WITH EFFICIENT HOODS AND EXHAUST SYSTEMS

Type of Workroom	No. of Samples	Particles of Dust per Cu. Ft.			Mg. of Dust per Cu. Ft.		
		Minimum	Maximum	Average	Minimum	Maximum	Average
Dry grinding shop—axe factory	10	51,500	400,000	154,000	0.0190	0.1010	0.0548
Cornering and light polishing shop—small-arms factory	8	22,000	720,000	195,000	0.0098	0.0422	0.0181
Heavy polishing shop—small-arms factory	7	52,200	854,000	204,000	0.0099	0.0672	0.0300

TABLE 15.—COMPARATIVE STUDY OF NUMBER OF DUST PARTICLES AND WEIGHT OF DUST IN AIR WITH HIGH AND LOW SUCTION HEADS

Sample No.	U-Tube Reading in Inches	Number of $\frac{1}{4}$ Standard Unit Particles per Cu. Ft. of Air	Mg. of Solids per Cu. Ft.	Sample No.	U-Tube Reading in inches	Number of $\frac{1}{4}$ Standard Unit Particles per Cu. Ft. of Air	Mg. of Solids per Cu. Ft.
6211	3.75	215,000	0.0295	6212	0.50	535,000	0.0292
6241	3.50	22,400	0.0105	6242	0.25	1,773,000	0.0605
6243	2.75	45,200	0.0098	6244	1.25	894,000	0.0275
6251 [1]	4.63	22,200	0.0085	6252 [1]	0.25	48,300	0.0156
6253	3.56	241,000	0.0104	6254	0.50	745,000	0.0193
6261	2.62	720,000	0.0193	6262	1.25	1,000,000	0.0422
6263	3.25	44,500	0.0148	6264	0.25	654,000	0.0293
6271	3.00	252,000	0.0422	6272	0.25	790,000	0.3620
7161	3.50	854,000	0.0672	7162	1.50	1,418,000	0.0382
7163 [2]	3.00	70,000	0.0153	7164 [2]	0.63	42,900	0.0106
7165	2.88	56,800	0.0130	7166	0.63	2,980,000	0.2120
7171	2.63	87,000	0.0553	7172	0.50	191,000	0.0102
7181	3.25	130,700	0.0099	7182	0.50	165,000	0.0270
7191	3.50	180,500	0.0240	7192	....	1,075,000	0.0748
7193	2.38	52,200	0.0254	7194	0.13	638,000	0.0802

[1] Operator worked only ten minutes.

[2] Very light operation.

Glaring defects in construction in all these respects are unfortunately only too common. Everyone who has examined exhaust systems, as actually installed, is familiar with the hoods designed by workmen unacquainted with the first principles of ventilation practice. Hoods may be observed which are so small and so badly placed that even the eye can note the stream of sparks missing their mouths by inches. Even when the hood is adequate in itself an exhaust duct connected at the rear of the hood, where the dust is being thrown off toward the top or the bottom of the wheel, will fall far short of its potential efficiency. The exhaust ducts themselves are often designed in violation of every law of physics. In another part of the same small-arms plant, in which are installed the excellent systems discussed above, is another exhaust system for a set of forge grinding wheels, the last section of which is a 6-inch pipe (28 square inches in cross-sectional area) into which four 5-inch pipes (combined cross-sectional area, 78 square inches) discharge. It is small wonder that the suction velocity in the last branch was found to be zero and that the dust content of the air of the workroom averaged 353,000 dust particles per cubic foot. Even in the well-arranged cornering and light polishing shop there were individual machines at which clogged wire mesh screens placed in the throat of the duct below the wheel reduced the velocity of the exhaust current from 900 to 500 feet per minute.

The strength of the exhaust draft maintained in the exhaust system is, of course, one of the chief factors in determining the efficiency of an installation of this kind. This is measured by drilling a small hole in the suction pipe and applying to this hole the end of a rubber tube connected to a glass U-tube containing a colored aqueous solution and backed with a scale on which can be read the difference in the level of the two arms of the U-tube produced by the negative head in the suction pipe.

A special study of the relation between suction head in the exhaust system and the dust content of the air of the workroom was conducted by us a year or more ago in the polishing shops of the small-arms plant, the normal conditions in which are indicated in Table 14 (24). Observations were made in pairs — first, under the normal conditions of operation of the exhaust system, and then, at the same point, after an interval of five or ten minutes, during which the suction head had been reduced by opening doors in the main exhaust duct between the point of examination and the exhaust fan. The results of this study are presented in Table 15.

It is evident that in general, other conditions being equal, a reduction in suction head is quickly followed by an increase in air dustiness. The dust counts with low exhaust pressure are relatively high, varying, with two exceptions, from 165,000 to 2,980,000 particles per cubic foot of air. It will be noted that while collecting sample 6252 the operator worked only ten minutes of the sampling time, and in the case of sample 7164 the operation was very light. The average of all the dust counts is 863,000 particles.

With the application of the normal, higher exhaust pressure the dust content is considerably lower, an average of all the samples being 200,000 particles. In this case there are again two samples, 6261 and 7161, which greatly increase the value of the average.

The average weight of solids per cubic foot of air is 0.069 milligram with the low exhaust pressure (averaging 0.56 inch), and 0.023 milligram with the high exhaust pressure (averaging 3.21 inches).

An examination of the corresponding observations in the two halves of Table 15 (the normal conditions being on the left, the reduced exhaust velocities on the right)

shows more clearly than the general averages just what was happening. In one case (samples 7163 and 7164) where only a very light operation was going on, the reduction of the suction head from 3 to 0.63 inches had no effect on the dust content. In every other instance the dust count went up when the suction was reduced, sometimes only a little — from 720,000 to 1,000,000 (6261–6262), or from 854,000 to 1,418,000 (7161–7162), or from 130,700 to 165,000 (7181–7182) — but usually very markedly. In five instances the count of dust particles increased more than tenfold — from 22,400 to 1,773,000 (6241–6242); from 45,200 to 894,000 (6243–6244); from 44,500 to 654,000 (6263–6264); from 56,800 to 2,980,000 (7165–7166); and from 52,200 to 638,000 (7193–7194). When all the results were plotted and a representative curve obtained, it appeared that in the two polishing shops in question a count of 700,000 dust particles or more was likely to be found with a suction head of 1 inch or less, while a count of about 500,000 corresponded to a 2-inch head, and a count of about 250,000 to a 3-inch head. Obviously such a relation will only hold in quantitative form for the particular type of polishing and the particular type of exhaust system which were studied in this individual case.

Control of Dust Hazard by Wearing of Respirators and Helmets

Finally, in certain industrial processes, as in packing operations, in marble and granite working, and in the sand-blasting of large castings, it is impossible by any of the means previously described to keep the air of the workplace free from dangerous concentrations of mineral and metallic (or poisonous) dusts. In such cases as this, the only alternative is the wearing of respirators which filter out the dust particles from the air before it is drawn into the respiratory tract, or of helmets which exclude the dusty atmosphere more or less completely from the mouth and nose and supply pure air for breathing from some other source. All such devices are uncomfortable and irksome to the wearer and the necessity for using them should be avoided wherever possible by the installation of the other devices which have been considered above. In certain employments, however, the respirator or helmet offers the only possible means of protection.

It is important, therefore, to determine the actual efficiency of the various types of respirators and helmets which are available, and such studies must be made with the particular dust and under the particular conditions with which it is desired to deal in practice. The Division of Industrial Hygiene of the New York State Department of Labor in a recent bulletin (27) has given a broad and sweeping endorsement to a respirator composed of one-half ounce of clean absorbent cotton in a layer 5 inches wide, 6 inches long, $\frac{3}{4}$ inch thick, pinned to a piece of cheese-cloth and tied over the nose and mouth. The bulletin states that dust-laden air containing a basic lead salt showed no trace of lead after passage through this layer of cotton. Nothing is said about the fineness of division of the lead dust, however, and it is questionable whether really fine dust could be effectively retained by such a device.

The most extensive previous studies of this subject which have come to our attention were made in the Hygienic Institute of the University of Berlin and are to be found in the Zeitschrift für Hygiene (28) (29). In the first of these papers Kobrak describes a special form of mask designed especially for protection against infections, droplets, and dust, and in the second paper Schablowski reports an extensive series of studies on the efficiency of various types of respirators used for protection against industrial dusts. Both observers used bac-

terial spores as a measure of the purifying effect executed by the devices studied. In Schablowski's experiments the various industrial dusts (cotton, cement, basic slag and rouge) were intimately mixed with a suspension of spores, redried, and blown into the air of an experimental chamber. A person equipped with one of the protective devices under examination, and a control individual with no such protection, entered the chamber, the noses of both being plugged with sterile cotton in amount sufficient to filter out the dust contained in the air without interfering too seriously with respiration. At the close of the experiment the cotton was washed in sterile water, gelatin plates were made, and the percentage removal of bacterial spores determined by comparing the count from the cotton in the nose of the unprotected individual with that in the nose of the individual wearing the mask or respirator. It was assumed that the removal of bacterial spores would correspond with the removal of the dust particles with which they were mingled. In a few cases control studies were made by direct chemical determinations of the amount of rouge collected by the cotton filters in the nose.

A large number of different types of respirators and helmets were studied by Schablowski, using the methods outlined above. The removal effected varied from 11 to 89 per cent., the latter result being attained by the use of the Kobrak mask with *Moellertuch* as a filtering material. The method used in these studies is ingenious, but the opportunities for experimental errors in the bacteriological technique involved are very considerable, and the assumption that the efficiency of dust removal will vary with the removal of bacterial spores mixed with the dust is a somewhat doubtful one.

A more recent study of the efficiency of respirators is reported by the Miners' Phthisis Prevention Committee of South Africa in its General Report issued in 1916 (10). Nine types of respirators were studied, a sugar filter being used to determine the respective dust content of normal mine air and of similar air passed through the respirators. Before blasting, the mine air contained from 0.028 to 0.28 mg. of dust per cubic foot, and the same air after passing the various respirators contained from 0.014 to 0.037 mg. The removal effected by the various types of respirators varied between 30 and 88 per cent. After blasting, the mine air contained from 1.16 to 1.78 mg. of dust per cubic meter and after passing through the respirators it contained from 0.368 to 1.78 mg. The removal effected varied from 0 to 77 per cent. The results obtained before and after blasting with the same respirator varied widely. For example, one type of respirator effected a 75 per cent. removal before blasting and produced no reduction at all after blasting. In view of these wide differences it seems probable that local variations in the dust content of the mine air must have been considerable.

It has seemed to us important to accumulate more accurate data in regard to the quantitative efficiency of various types of respirators and helmets in actual use in the United States and last year the opportunity was offered to conduct a study of this kind under unusually favorable conditions (30). Our observations were made in a sand-blast cabinet used for the sand-blasting of castings and forgings in an automobile plant, and this represented one of the most extremely dusty environments to be met with in any industry. The sand-blast operators in this plant were provided with respirators of the ordinary "muzzle" type with a rubber body fitting over mouth and nose, an air filter composed of two layers of muslin having about 75 meshes to the inch, and a piece of sponge about $2\frac{1}{2}$ by 3 by 1 inch, and fitted with an air outlet valve. They were also supplied with hel-

mets made of cloth-covered cardboard, provided in front with a 3 by 4½-inch window of 40-mesh wire gauze, through which the operator could see the work, and provided also with an inlet tube on top for fresh-air supply. The helmet was fitted with a string by means of which the apron or lower portion could be drawn tightly around the neck, thus making a fairly air-tight covering with the exception of the wire gauze-covered portion in front.

In using these protective devices the operator as a rule first placed a handkerchief over his nose and mouth, tying it in a knot at the back of his head, then placed the respirator in position, and finally put on the helmet. The workers prior to our investigation did not make use of the air inlet at the top of the helmet, intended to be connected with a fresh-air supply line, for the reason that the fresh-air supply as drawn from the general supply air compressor was contaminated with oil, which produced a very disagreeable odor when blown into the helmet in large quantities. Furthermore, it was difficult by means of the valves as installed to control the quantity of air supplied to the helmet; and, lastly, the fresh-air line entered the cabinet at one side, so that the length of unsupported hose necessary when working in the center of the chamber created an uncomfortable drag on the worker's head.

For collecting the dust samples we used the Palmer water-spray apparatus. The sampler was set up on a table in the sand-blast cabinet at about the height of the worker's head, while work was in progress as usual. The apparatus was protected against the direct blast of the sand by a covering of heavy wrapping paper. To the air inlet was attached a sampling tube 1 inch in diameter and 17 inches long, terminating in a funnel-shaped opening 3 inches in diameter. With the funnel open we obtained samples of the normal air of the cabinet, and with the respirator held in position over the end of the funnel by means of rubber bands we determined the filtering effect of this device. In testing the efficacy of the helmet the funnel, with or without the respirator, could be placed inside the helmet, which was supported on a specially constructed wire frame. The general results of this investigation are presented in Table 16.

TABLE 16.—EFFICIENCY OF RESPIRATOR AND HELMET IN REDUCING DUST CONTENT OF AIR OF A SAND-BLAST CABINET

Source of Samples	No. of Samples	Number of Dust Particles per Cu. Ft.			Mg. of Dust per Cu. Ft.		
		Minimum	Maximum	Average	Minimum	Maximum	Average
Untreated air of cabinet	10	15,000,000	82,000,000	60,880,000	12.43	119.80	55.29
Air passed through respirator alone	8	1,370,000	7,070,000	4,549,000	0.19	2.86	1.26
Air passed through helmet-respirator	19	369,000	4,480,000	2,047,000	0.03	1.46	0.24
Air passed through helmet with positive air supply	10	118,000	1,529,000	368,000	0.01	0.08	0.04
Air passed through helmet with positive air supply and respirator	22	18,000	329,000	156,000	0.01	0.09	0.03

In the particular series of tests in which the respirator alone was used the average dust content of the normal air of the cabinet averaged 49,400,000 particles per cubic foot and the air which had passed through the respirator, only 4,549,000. These results were somewhat more favorable than those which could be expected in practice, since the respirator fitted our sampling funnel more closely than it would be likely to fit the face of a worker.

From the standpoint of the actual dust

content of the air which would be respired by a sand-blaster, the use of the respirator alone evidently fails to provide an adequate protection. The dust content of the air after passing the respirator (varying from one to seven million, and averaging 4,549,000 particles per cubic foot) was still excessively high. From the standpoint of per cent. removal, on the other hand, the respirator showed a high efficiency which should make it a fairly satisfactory protective device for use in a workplace where the initial dust content was not so enormously high. The respirator studied by us removed about 92 per cent. of the dust present by count, and 97 per cent. by weight. The results on a basis of number of dust particles compared with the best of those obtained by Schablowski, and the results by weight are much better than those reported by the South African Commission. The conditions are not comparable, however, in view of the different dusts with which the respirators had to deal in the two cases. The dust content of the air of the South African mines, even after blasting, was only from 1.2 to 1.8 mg. per cubic foot as against 12.4 to 27.2 mg. in our case. The larger the amount of dust present in the air (and the larger the individual particles), the greater will be the per cent. purification. Weight determinations are in any case of little value since the larger particles — those of least sanitary significance — will be the ones most readily removed by any filtering device. The South African study includes only weights, but it is the count of small (one-fourth standard unit) particles which is really significant.

The use of the helmet and respirator in combination, but without a positive air supply to the interior of the helmet, produced a reduction from an average of 58,330,000 dust particles per cubic foot of air to an average of 2,355,000 — a reduction of 96 per cent. These results are, of course, distinctly better than those obtained with the respirator alone, but the air was still too dusty to be respired with safety. Evidently the use of positive air pressure within the helmet was essential in this exceedingly hazardous occupation.

In conducting the tests with positive air pressure the sampling tube, with respirator in place, was set inside the helmet and to the $\frac{1}{4}$-inch inlet at the top of the helmet was attached an air line delivering air through a flow meter. Since the Palmer apparatus, during the period of sampling, was removing air from the interior of the helmet at a rate of 2 cubic feet per minute, it was necessary to supply air in excess of this amount in order to preserve a condition of positive pressure within the helmet. We therefore adjusted the valve on the air line so that the amount of air actually delivered to the helmet was in the neighborhood of 3 cubic feet per minute (ranging from 2.3 to 3.7 cubic feet per minute). The results of nineteen such observations on five different occasions showed that the dust content of the air collected in this way, with an average air supply of 2.9 cubic feet per minute to the interior of the helmet, ranged from 18,000 to 329,000 one-fourth standard unit particles and averaged only 151,000 such particles per cubic foot.

These results were so encouraging, and indicated so clearly the value of positive air pressure in excluding dust, that it seemed of interest to determine the efficiency of the helmet alone, provided with positive air pressure but without the use of the respirator. We therefore set the apparatus up as before but without the respirator and, on two different occasions, collected the dust from ten samples of air in this way, with three control samples in which the respirator was present. The air supply to the interior of the helmet was about the same as before, ranging from 2.4 cubic feet to 3.1 cubic feet and averaging 2.7 cubic feet per minute. The results of this study were not quite so good as those obtained

with the use of the respirator, but the difference was comparatively slight. The dust counts without the respirator ranged from 118,000 to 355,000, except for one count of 1,529,000, and the average, including this aberrant count was 368,000 particles per cubic foot. If the one exceptional count were excluded, the average for the group would be only 239,000 particles per cubic foot. The weights obtained in this way without the respirator ranged from 0.01 to 0.08 mg. per cubic foot and averaged 0.04 mg. per cubic foot.

These results appear to us to be of considerable general interest as indicating the possibility of excluding dust from the respiratory tract of the worker by maintaining a positive air pressure in a comparatively impermeable inclosure about the head, rather than by attempting to filter the incoming air through a close-grain respirator. In processes where the workman must move about over a wide area such a method of protection would not be feasible, but in the sand-blasting cabinet it is altogether practical to use positive air pressure.

In regard to the amount of air to be supplied to the helmet in practice, it should be noted that we used, on the average, somewhat less than 3 cubic feet per minute, while the Palmer apparatus was constantly removing 2 cubic feet per minute. In other words, the pressure at the front window of the helmet was produced by an excess of air supply over the air exhaust through the Palmer apparatus of less than 1 cubic foot per minute. In practice it would be necessary to maintain a corresponding excess of air supply over the amount withdrawn from the helmet during inspiration. Assuming that for the type of physical effort required in sand-blasting each inspiration removes 90 cubic inches of air in a period of 1.5 seconds, the draft upon the air in the helmet, during the inspiration period, would be at the rate of approximately 2 cubic feet per minute. A gross air supply to the helmet of 2.5 to 3 cubic feet per minute should, therefore, prove ample to maintain satisfactory conditions in practice.

The solution of the odor problem (which, as noted above, has proved troublesome in the plant where our studies were made) has proved comparatively simple. We found that only when large quantities of air were allowed to enter the helmet was the odor of oil noticeable. With the air supply to the helmet reduced to 3 cubic feet per minute, we were ourselves unable to detect any odor in the air supplied. If trouble of this kind should be experienced, there are on the market simple and inexpensive air filters which may be placed in the air line to remove any impurities present. The use for the fresh-air supply of a small impeller type blower which does not use lubricating oil internally would, of course, solve this difficulty completely.

It is evident from these studies that both respirators which filter the incoming air and helmets which exclude the dusty atmosphere by an interior positive air pressure may be highly efficient under certain conditions in protecting the worker against the hazards of industrial dusts. Whether such devices are actually adequate in a given case can only be determined by actual tests such as those which have just been described.

Importance of Definite Analytical Standards in Control of Industrial Dust Hazards

If real progress is to be made in the control of the industrial dust hazard, it is important that standards of a reasonably definite nature should be established by which the adequacy of protective devices can be judged in any given case. For the most part, such standards have been completely lacking in the past. There are many state laws which deal with this problem but, as a rule, only in terms so general

as to be of no practical value. It is not particularly helpful to provide that dusts shall be removed "as far as practicable" or "as far as the nature of the business permits" or "when inhaled to an injurious extent," if the inspector charged with the enforcement of the law has no way of judging how dusty the air of a given workroom is or how far its dust content could be practically reduced.

In connection with exhaust systems for grinding and polishing shops, several industrial codes contain more specific regulations, dealing almost exclusively, however, with the mechanical details of construction and with the minimum static head to be maintained in the exhaust ducts. Thus, according to the Wisconsin code:

> On all grinding, buffing, and polishing wheels, the suction in the connection to the hood must be sufficient to displace a column of water in a U tube, 5 inches.
>
> The test for suction with the U tube must be a static test and must be made in the following manner: A hole $\frac{1}{8}$ inch in diameter must be made in the suction pipe approximately 12 inches from the connection to the hood. The rubber hose attached to the U tube must be placed over the $\frac{1}{8}$-inch hole and the test made under these conditions. When the water in the U tube stands at 0, the 5-inch displacement is secured when one column of water rises $2\frac{1}{2}$ inches above 0 and the other column of water falls $2\frac{1}{2}$ inches below 0.

The New Jersey code requires that:

> Sufficient suction head shall be maintained in each branch pipe within 15 inches of the hood to displace 2 inches of water in a U-shaped tube. Pressure to be taken by pressing tube attachment over small opening through pipe, commonly called static method. Tests to be made with all branches open and unobstructed.

The New York code reads:

> Sufficient static suction shall be maintained in every branch pipe within 1 foot of the hood to produce a difference of level of at least 2 inches of water between the two sides of a U-shaped tube. Test shall be made placing one end of a rubber tube over a small hole made in the pipe, the other end of tube being connected to one side of U-shaped water gauge. Such test shall be made with all branch pipes open and unobstructed.

The head, as thus measured, includes both velocity and frictional components, and it is obvious that it bears no necessary relation to the velocity of the exhaust at the face of the wheel itself. The state codes, to which reference has been made, do, it is true, specify the size of the exhaust piping to be installed for a wheel of any given size, but the form of the hood and its arrangement in relation to the grinding process will materially affect the results obtained, while any obstruction to air flow between the wheel and the point where the suction head is measured will reduce the actual efficiency obtained with a given suction head.

For such reasons the standard which depends only on suction head in the exhaust pipe seems to us inadequate as a measure of the actual protection afforded to the workers, and the difference between the New York and New Jersey standards of 2 inches and the Wisconsin standard of 5 inches indicates that the evidence upon which even this imperfect standard has been based must be somewhat inconclusive.

A more valuable sort of standard from the sanitary standpoint would be one based on actual velocity of exhaust at the point of dust production, instead of suction head in the duct below. Such a standard was suggested by the British departmental committee on the lead hazard in the pottery industry (6) in the form of the very mild recommendation that a speed of 100 linear feet per minute should be maintained at the point of dust production.

The only standard that can be altogether satisfactory to the sanitarian, however, is one that deals directly with the actual condition of the air inhaled by the worker. It is well that certain definite suction heads and air velocities should be maintained, but what we really want to know is whether the dust has actually been removed. Mechanical standards are con-

venient and easy of application, but it is the actual state of the atmosphere that is of primary importance. What we must ultimately rely upon in the future is a standard that rests upon the number of dust particles actually contained in the air breathed by the worker.

So far as we are aware only three efforts have so far been made to set definite standards of this kind for industrial dusts. The earliest of these attempts was made by the Miners' Phthisis Prevention Committee of South Africa, reference to whose report (10, p. 21) shows that they were fully cognizant of the difficulty and the novelty of the problem. To quote:

> 69. The committee, being desirous of taking immediate steps to cope with the disease, was confronted with the difficulty that no standard of purity with regard to dust existed to which to work. In order to assist in arriving at such a standard, tests of the amount and the character of the dust in the street air of Johannesburg were taken, as affording some basis of comparison. At the same time, it was soon discovered by experiment that it was practically impossible to remove by dust allaying devices all the dust from either underground or surface air. The question arose as to what weight per cubic meter could be considered permissible, and as this was more or less a matter for conjecture the committee decided, for the time being, to adopt the tentative standard of 5 mg. of dust to the cubic meter of air. This figure was at the time supposed to represent the average amount of siliceous dust under 70 microns diameter present in the air of a Johannesburg street, but on account of the great difference in character and the proportion of "injurious" dust between mine and street dust, the direct comparison of weights may be misleading.
>
> The amount of "injurious" dust which air can carry without being dangerous has not yet been determined, and indeed can only be ascertained by experience.

Another attempt to set a standard for the dust content of air was made by Higgins, Lanza, Laney, and Rice (8) in their very complete study of the mines in the Joplin district, Missouri. They say:

> The most reasonable standard then appears to be one based on the quantity of dust that will remain in suspension after the best known methods have been put into use for its abatement.
>
> It has been demonstrated in the sheet ground mines of the Joplin district that by the proper use of water and the regulation of certain details of mining the quantity of dust in the mine air can be kept below 1 milligram per 100 liters of air; so it seems reasonable to use 1 milligram as a standard at least for the Joplin district.

In an earlier paper (24) we have attempted to formulate practicable standards for estimating the adequacy of exhaust systems installed in grinding and polishing shops, based on our own studies of well-equipped systems of this type, in accord with the principle laid down some years ago by the Massachusetts State Board of Health that in fixing standards of industrial hygiene it was reasonable to require that conditions should be maintained in any industry approximately equal to those already found in the best plants of that industry in actual operation.

In the best installations of this kind that we have studied we find the suction head in the exhaust pipes varying between 2 and 5 inches and averaging somewhat over 3 inches. A fall to 1.25 or 1.50 inches, when the exhaust was reduced for experimental purposes, was at once followed by a marked increase in air dustiness. It would appear from these observations that the 5-inch suction head called for by the Wisconsin code is unnecessarily severe, while the 2-inch head specified in the New York and New Jersey codes is a trifle lenient. For an absolute lower limit it is perhaps scarcely possible to go much beyond this figure, but we would suggest that a fairer measure of actual performance would be obtained by specifying that the suction head in the exhaust pipes of a polishing shop should at no point fall below 2 inches, and should average 3 inches when measured at a number of different points.

The next point of interest is the linear velocity of the exhaust air current maintained at the throat of the exhaust duct.

This velocity in installations that are operating satisfactorily generally varies from 1500 to 5000 feet per minute and has averaged in our studies about 2500 feet per minute, while a lowering of the velocity below 1500 feet has been promptly followed by an increase in the dust content of the air.

We have found in the examination of polishing shops equipped with well-designed exhaust systems that it is perfectly possible to keep the weight of dust in the air in the proximity of the wheels down to an average of 0.03 mg. per cubic foot with maximum figures not rising above 0.06 mg. In grinding shops the weights are likely to rise somewhat higher, the results for such a workroom presented in Table 14, for example, rising to 0.05 mg. for an average and 0.1 mg. for a maximum. We may tentatively conclude that in a polishing shop the weight of dust in the air can be constantly kept below 0.06 mg. per cubic foot and should not average over 0.03 mg., while for a grinding shop these values should perhaps be doubled. These figures are lower than the standards of 0.14 mg. per cubic foot and 0.28 mg. per cubic foot set, respectively, by the South African commission and by Higgins and Lanza for mine air; but it is obvious that the air of a polishing shop can, and therefore should, be kept freer from dangerous dust than that of a metal mine.

It has been pointed out above that it is the small dust particles which are of chief importance, so that a standard based on the number of one-fourth standard unit (1–10 microns) particles in the air should prove even more valuable than one based on weight. So far as the number of small dust particles is concerned, there is no great difference between well-equipped grinding and polishing shops. In either case, our studies indicate that the dust content of the air can be kept generally under 300,000 one-fourth standard unit particles per cubic foot and should not average over 200,000 such particles.*

These standards are only tentative and must be subject to revision with the development of a wider knowledge of the air conditions in representative workrooms. They are, in any case, applicable only to grinding and polishing shops, and the standards which can reasonably be applied in other processes must be determined by similar studies under actual working conditions. The carrying out of such studies on a large scale and in many different industrial processes is essential to the formulation of standards of air dustiness which shall place this important branch of industrial hygiene upon a firm foundation.

* All data in this paper were obtained with the Palmer apparatus and standards must, of course, be modified if a method is used which gives higher values for a given sample of air.

BIBLIOGRAPHY

(For bibliographical references numbered less than 15, see Part I of this article in the preceding issue of this Journal.)

15. Hill, E. V.: Quantitative Determination of Air Dust. Heating and Ventilating Magazine, 1917, **14**, 23.
16. Macfadyen, A., and Lunt, J.: Bacteria and Dust in Air. Trans. Brit. Inst. Prev. Med., 1897, **1**, 142.
17. Palmer, G. T.: A New Sampling Apparatus for the Determination of Aërial Dust. Am. Jour. Pub. Health, 1916, **6**, 54.
18. Final Report of the Committee on Standard Methods for the Examination of Air. Am. Jour. Pub. Health, 1917, **7**, 54.
19. Inness, J.: The Estimation of Injurious Dust in Mine Air by the Kotzé Konimeter. Jour. Chem. Met. Min. Soc. So. Africa, 1919, **19**, 132.
20. Bill, J. P.: The Electrostatic Method of Dust Collection as Applied to the Sanitary Analysis of Air. Jour. Indust. Hyg., 1919–1920, **1**, 323.

21. Katz, S. H., Longfellow, E. S., and Fieldner, A. C.: Efficiency of the Palmer Apparatus for Determining Dust in Air. Jour. Indust. Hyg., 1920–1921, **2**, 167.
22. Report (Fourth Supplementary) of the Committee on Standard Methods for the Examination of the Air. Am. Jour. Pub. Health, 1920, 10, 450.
23. Miller, T. G., and Smyth, H. F.: The Dust Hazard in Certain Industries. Jour. Am. Med. Assn., 1918, **70**, 599.
24. Winslow, C.–E. A., Greenburg, L., and Angermyer, H. C.: Standards for Measuring the Efficiency of Exhaust Systems in Polishing Shops. U. S. Pub. Health Rep., 1919, **34**, 427.
25. Winslow, C.–E. A., Greenburg, L., and Greenberg, D.: The Dust Hazard in the Abrasive Industry. U. S. Pub. Health Rep., 1919, **34**, 1171.
26. Palmer, G. T., Coleman, L. V., and Ward, H. C.: A Study of Methods for Determining Air Dustiness. Am. Jour. Pub. Health, 1916, **6**, 1049.
27. A Simple and Inexpensive Respirator for Dust Protection. N. Y. State Dept. Labor, Bull. No. 90, Dec., 1918, pp. 10.
28. Kobrak, E.: Respiratoren zum Schutze gegen die Einatmung Infektiöser Tröpfchen und Stäubchen. Ztschr. f. Hyg., 1911, **68**, 157.
29. Schablowski: Ueber Respiratoren bei Gewerblichen Staubarbeiten. Ztschr. f. Hyg., 1911, **68**, 169.
30. Winslow, C.–E. A., Greenburg, L., and Reeves, E. H.: The Efficiency of Certain Devices Used for the Protection of Sand Blasters against the Dust Hazard. U. S. Pub. Health Rep., 1920, **35**, 518.

BOOKS RECEIVED

Books received are acknowledged in this column, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

Motion Study for the Handicapped. By Frank B. Gilbreth, Major, Engineers, R. C. (honourably discharged), Consulting Management Engineer, Member Franklin Institute, American Society of Mechanical Engineers, Past Vice-President Society for the Promotion of Engineering Education, Author of *Fatigue Study*, *Applied Motion Study;* and Lillian Moller Gilbreth, Ph.D. Cloth. Pp. 165, with illustrations. London: George Routledge & Sons, Ltd.; New York: E. P. Dutton & Company, 1920.

The Major Symptoms of Hysteria. Fifteen Lectures Given in the Medical School of Harvard University. By Pierre Janet, Ph.D., M.D., Member of the Institute of France, Professor of Psychology in the Collège de France. Second edition with new matter. Cloth. Pp. 345, with illustrations and index. New York: The Macmillan Company, 1920.

The Human Factor in Industry. By Lee K. Frankel, Ph.D., Third Vice-President, and Alexander Fleisher, Ph.D., Assistant Secretary, Metropolitan Life Insurance Company, with the co-operation of Laura S. Seymour. Cloth. Pp. 366. New York: The Macmillan Company, 1920.